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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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An Investigation of X Radiation from Color Television Receivers in Suffolk County, New York

Seymour Becker[1]

The results of an investigation of color television receivers at the homes of 6,482 residents in Suffolk County, who requested a radiation inspection after publication of the proposed study in the newspapers, is presented.

The survey consisted of two parts:

1. an investigation of only General Electric color television sets from July 1967 through August 1967; and
2. a radiation inspection of General Electric and 39 other types of television receivers requested by owners from January 1968 to December 31, 1969.

X-radiation emissions were detected in 37 of the 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guides. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set.

X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

During the summer of 1967, the Surgeon General's office of the United States Public Health Service issued a public statement that General Electric (G.E.) color television receivers were suspected of emitting x radiation at levels higher than desirable.

As a result, an investigation by the Suffolk County Department of Health (SCDH) was commenced in Suffolk County to locate the G.E. color television sets. At the time of the inspection a spot check of other television manufacturers' sets was conducted. It was found that other brand-name color television receivers also emitted levels of x radiation above the recommendations of the National Council on Radiation Protection and Measurements (NCRP).

In 1959, the NCRP had released a statement concerning x rays produced in home television receivers. In part the statement reads:

> "To insure that the television contribution to the population gonad dose will only be a small fraction of that due to natural background radiation, the NCRP recommends that the exposure dose rate at any readily accessible point 5 cm from the surface of any home television receiver shall not exceed 0.5 mR/hr [sic] under normal operating conditions."

Due to a limited staff at the SCDH, priority was given to inspection of G.E. color television sets only. With the cooperation of representatives from the G.E. regional office in Suffolk County, the investigation revealed that 87 of the nearly 500 G.E. color television sets checked required modification for compliance with the NCRP guidelines. Since the percentage of noncomplying G.E. color TV receivers was significant (17.4 percent), the Commissioner of Health, as well as the Director of the Division on Environmental Health, decided that, as a service to Suffolk County residents, the color television set survey should continue and include all makes of color television sets.

Description of survey

In order to facilitate locating the color television sets in Suffolk County, a press release was sent to all local daily and weekly newspapers and to radio stations. A statement was made that any owner of a color television set should contact the SCDH. Within the first weeks of the public announcement, approximately 3,000 requests by telephone and mail were received from Suffolk County resi-

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[1] Mr. Becker is chief, Radiation Control Unit, Division of Environmental Health, Suffolk County Department of Health, Riverhead, N.Y.

dents and from residents of neighboring areas (Nassau County, New York City, and Westchester County). Calls from outside Suffolk County were referred to the Department of Health having jurisdiction.

Representatives from the Bureau of Radiological Health (BRH) of the U.S. Public Health Service (PHS) visited the Suffolk County Department of Health at the request of SCDH to determine if the detecting instruments used were consistent with those of the PHS. A random survey was made throughout the county, and the representatives acknowledged that the detecting instruments used by the local health unit (Victoreen 440 R.F. and Victoreen G.M. counter-open-window probe 1B85) were suitable for the detection of low energy x radiation.

The requests from Suffolk County television set owners were listed by towns (there are ten towns in the county) in order to simplify the scheduling of inspections. Commencing in January 1968, a visit to each television set owner who had requested inspection of his set was arranged. A telephone call was made on a day-by-day schedule by the SCDH to the television set owner listed for an appointment. Initially, an average of 18 visits was made daily, decreasing as requests for this service tapered off. At each inspection, the owner of the television set was requested to turn the set on, move the set if necessary to facilitate testing and upon completion of the inspection, turn the set off. The detecting probe scanned the television cabinet approximately 5 cm from the surface of all accessible areas (including under the set). When the detecting instrument indicated net readings of 0.5 mR/h or above, the owner of the television set was informed. Any discussion of possible radiation hazards was discouraged since the function of the survey was to find out if the television set was in compliance with the NCRP recommendations. However, as a precautionary measure, in accordance with PHS recommendations, a suggestion was made to the television set owner to see that he and his family sit at least 6 feet from the sides or front of the set when viewing television programs.

The manufacturer or a local television serviceman was then notified of the significant findings by a representative of the SCDH or the owner of the television set. Generally, an authorized or independent television serviceman or the manufacturer's representative, accompanied by an electronics engineer, was dispatched to service the set. When the cause of the x-radiation emissions was determined and corrected, the detecting equipment on a resurvey would indicate levels of radiation at natural background.

As of December 31, 1969, 6,482 color television sets had been inspected (table 1). Approximately 16.2 percent of the receivers checked were found to be emitting x radiation above the NCRP recommendations.

The general causes of the x-radiation emissions from a color television set were:

1. manual manipulation of the high voltage control on the high voltage shunt regulator tube;
2. anode and cathode components of the high voltage shunt regulator tube not properly aligned,
3. replacement of a high voltage shunt regulator tube with another unaligned tube by the television serviceman. On most initial inspections and on re-inspections by representatives of the SCDH, it was learned from the television serviceman that he did not use a voltmeter. Therefore, he would automatically replace the high voltage shunt regulator tube. In some revisits, the investigators found a higher x-radiation leakage after the service adjustments had been made. Further investigation revealed that in most cases a faulty 6BK4 high voltage shunt regulator tube had been installed by the television serviceman;
4. defective high voltage rectifier tube;
5. circuit failure caused by a breakdown of the capacitor in the high voltage regulator component;
6. defective resistor component which caused the high voltage regulator to function improperly;
7. connector to the high voltage shunt regulator tube's positive terminal not affixed properly;
8. defective power transformer causing malfunction of other components which emitted x rays;
9. high voltage cage not grounded causing malfunction of other components;
10. ground strap on yoke of picture tube not installed properly causing malfunction of other components;
11. increase of outside line voltage;
12. cathode-ray tube lacking adequate shielding;
13. shielding on the high voltage cage not installed;
14. failure of serviceman to meter and adjust the high voltage upon installation of the sets in the consumer's home; and

Table 1. Results of color television receiver inspections

Color television receiver (brand or manufacturer)	Number of television receivers with an exposure rate before corrections at 5 cm from surface of television set of:[a]					
	≤0.5 mR/h	>0.5–<1.0 mR/h	1.0–<10.0 mR/h	10–<16 mR/h	≥16 mR/h	Total
Admiral	430	62	58	2	1	553
Ambassador (Emerson)	4	3	2			9
A.M.C. (A&S)	5	2	1			8
Andrea	22	3	2			27
Arvin	2	1	0			3
Clairtone	18	2	1			21
Cornelia	1	0	0			1
Curtis Mathes	33	3	5			41
Delmonico	11	3	6			20
Dumont	19	5	1			25
Emerson	56	3	6			65
General Electric	433	43	47	4	1	528
Grants Bradford	53	11	9	2	2	77
Heathkit	30	3	1			34
Hitachi	6	1	0			7
Hoffman	1	0	0		1	2
JVC	1	0	0			1
Macy's Supre-Macy	11	7	7			25
Magnavox	526	52	26	2	5	611
Montgomery Ward Airline	22	2	9			33
Motorola	221	29	23	1		274
Munts	2	1	0			3
Olympic	41	2	4			47
Packard Bell	3	1	1			5
Panasonic	25	4	1			30
Penny's Penncrest	29	2	7			38
Philco	221	7	10			238
RCA	1,450	116	55	7	1	1,637
Sears/Japanese	70	11	18			99
Sears/Silvertone	202	15	6			223
Setchell Carlson	12	8	5	2		27
Sharp	5	1	0			6
Singer	2	0	0			2
Sylvania	441	37	8			486
Symphonic	2	1	0			3
Telefunken	2	1	0			3
Truetone (Spiegel)	2	1	0			3
Toshiba	10	1	1			12
Westinghouse	34	2	8			44
Zenith	963	116	123	7	2	1,211
Grand total	5,429	562	451	27	13	6,482

[a] 16.2 percent of television receivers were above the recommended NCRP guidelines as of December 31, 1969.

15. the three color electron guns not operating independently of each other. X radiation had been detected when the colors were faded out and more white than other colors was visible at the viewing area.

During the initial phase of the investigation, a record was kept of the model number, date of purchase, size of screen, and type of cabinet (wood or metal) of each receiver. Shortly after the investigation began, this procedure was terminated because x radiation had been detected beyond the measured distance recommended by the NCRP guidelines regardless of model, age of set, screen size, or type of cabinet, if any of the previously listed causes were present.

If the high voltage was determined by the serviceman to be above 30,000 volts, x radiation was detected emanating from various parts of the television set, front, top, back, sides, and underneath. On most of the television receivers producing exposure rates above 10 mR/h at 3 to 6 inches from the receiver surface the TV serviceman reported high voltage readings above 30,000 volts.

At the request of an Air Force Base, a spot check was made on television sets on the base that had been purchased outside Suffolk County. The investigation of these sets revealed causes of x ray emission similar to those found in television sets purchased in Suffolk County.

Summary

Representatives of the Suffolk County Department of Health visited homes of 6,482 owners of color television sets in the county. X-radiation emissions were detected in 37 of 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guidelines. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set. Five hundred and sixty-two color television sets emitted x rays above 0.5 to less than 1.0 mR/h, 451 color television sets emitted x rays from 1.0 to less than 10.0 mR/h, 27 color television sets emitted x rays from 10 mR/h to less than 16 mR/h, and 13 color television sets emitted x rays in the

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range of 16 mR/h to 150 mR/h. Those color television sets that emitted x radiation above 10 mR/h at 5 cm were observed to have a high voltage of more than 30,000 volts on a calibrated voltmeter.

The outstanding causes of x-ray emissions were improper adjustments of the high voltage control which caused the voltage to exceed the factory specifications, faulty high voltage shunt regulator tube, and replacement of one faulty high voltage shunt regulator tube with another faulty one by the television serviceman. X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

Acknowledgment

The writer wishes to express his appreciation for the encouragement and assistance received throughout the entire investigation to Dr. G. H. Leone, Commissioner; Mr. H. W. Davids, Director, Division of Environmnetal Health of the Suffolk County Department of Health; Mr. D. Smith, Mr. S. Harris, and Mr. R. H. Schneider of the U.S. Public Health Service, Bureau of Radiological Health; and Mr. H. Farkas, Associate Engineer of the Bureau of Radiological Health, New York State Health Department.

7

Strontium-90 in Human Bones in the United States, 1962–1966

E. J. Baratta, E. S. Ferri,[1] and *M. A. Wall*[2]

The Bureau of Radiological Health has been conducting a continuous investigation of strontium-90 in human bones since late 1961. Autopsy specimens, mostly vertebrae, were collected by pathologists, medical examiners, and coroners in selected areas throughout the United States. The population of interest consisted of children and young adults up to 25 years of age. Samples were collected from areas around six principal cities: Atlanta, Boston, Cincinnati, Los Angeles, New Orleans, and Seattle.

From 1962 through 1966, over 1,600 specimens have been analyzed. The specimens were grouped and analyzed according to age and year of death. A review of the data shows that peak strontium-90 levels occurred in most age groups during the years 1963 and 1964. Decreasing values approaching those of 1962 are shown in analyses for 1966. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

Since late 1961, the Bureau of Radiological Health has conducted a program for the determination of strontium-90 in human bones (*1-4*) similar to the one previously conducted by Kulp (*5*) in 1961. The population from which bone samples are obtained is composed of individuals under 25 years of age, thereby including the age group whose bones are being formed at the fastest rate. This report summarizes the data for 1962 through 1966. The specimens are normally obtained from accident victims, but some are selected from those who have died from other causes. All specimens are selected to exclude those whose history reflected a calcium deficiency.

The samples are collected principally from areas around six cities: Atlanta, Ga.; Boston, Mass.; Cincinnati, Ohio; Los Angeles, Calif.; New Orleans, La.; and Seattle, Wash. (figure 1). The areas also include other cities and towns in the United States. Over 1,600 bone specimens collected from 1962 through 1966 have been analyzed.

Samples normally collected are vertebrae or ribs as these specimen types are readily obtainable on autopsy. Specimen collection is made possible through the cooperative efforts of pathologists in various hospitals throughout the country.

Analysis

Prior to 1963, the samples were analyzed by a procedure similar to Volchok's (*6*). Since 1963, the analytical methods used are those presented by Baratta and Ferri (*7*) and Magno, Baratta, and Ferri (*8*). A number of human bone samples were analyzed by both methods, and an analysis of variance of the data showed no significant difference between the results of the two methods.

For purposes of maintaining analytical quality control "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, "spiked" synthetic bone ash samples are analyzed routinely. A cross check program with the Health and Safety Laboratory of the Atomic Energy Commission was conducted monthly. Results for this program over the past 2 years show satisfactory agreement between the two laboratories.

Discussion

Table 1 lists the levels of strontium-90 in human bone in pCi ^{90}Sr/g Ca for the years 1962 through 1966. The age groups are broken into 0-5 months, 1 year, 2, 3, 4, 0-4, 5-9, 10-14, and so forth. The data indicate that the levels of ^{90}Sr/Ca in pCi/g in most of the age groups reached a peak in 1963 to 1964. This was expected, since strontium-90 in fallout from above ground nuclear tests of 1961 and 1962 reached its peak in air and milk in 1963 and 1964.

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[1] Northeastern Radiological Health Laboratory, Winchester, Mass. 01890.

[2] Mrs. Wall is now with the Materials Research Command, U.S. Army, Natick, Mass.

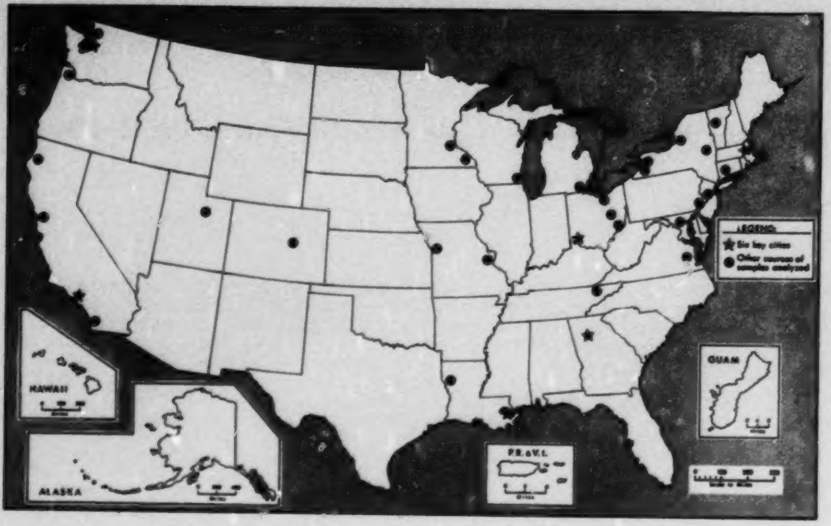

Figure 1. Human bone sampling locations

The median strontium-90 to calcium ratio plotted against age and year of collection is shown in figure 2. It can be noted that, in general, the strontium-90 to calcium ratios for bones collected in 1966 approached the levels found in bones collected in 1962. The strontium-90 to calcium ratio found in bones of the 0-4 year age group collected in 1966 is approximately the same as the levels found in bones collected in 1965, with the exception of the 2-year-old children. The 1963 and 1964 ratios of strontium-90 to calcium appear to be similar to each other for all age groups. Also similar are the strontium-90 to calcium ratios for 1965 and 1966, with the exception of the already noted difference. The strontium-90 to calcium ratios for bones collected in 1962 were generally lower than those for the other years.

The data for the earlier years, up to 1965, have been compared previously with the data from Germany, England, and the U.S. Atomic Energy Commission in the 0-4 and 5-19 age groups (*3,6, 9-12*). The values are not dissimilar when allowing for differences in sampling techniques and geographic locations.

As in previous reports for 1962 to 1965 (*1-4*), the data were compared with Federal Radiation Council's (FRC) Radiation Protection Guides (RPG). FRC Report No. 2 (*13*) presents three ranges of radionuclide intake for guidance during normal peacetime operations. For strontium-90, the FRC Report stated that a continuous intake of 200 pCi/day over a period of 1 year would correspond to ⅓ of the Radiation Protection Guide (0.17 rad/a) to mineral bone for a suitable sample of an exposed population. This would result in an average skeletal concentration in the exposed population of one-fourth of that in the diet (50 pCi/g Ca). The FRC Report No. 7 (*14*) presented a more detailed discussion on dosimetry considerations. It stated that 1 nCi of strontium-90/g of calcium in adult bone would result in a dose of 2.7 rad/a to the mineral bone. Therefore, the concentration corresponding to ⅓ of the RPG (0.17 rad/a) would be 63 pCi ^{90}Sr/g Ca. This report also states that dose to mineral bone of the fetus and infant may be one-half that of the adult value

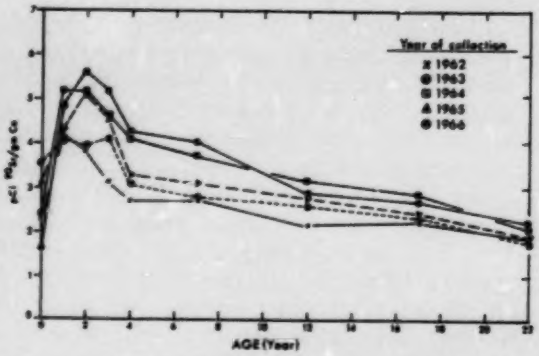

Figure 2. Plot of median strontium-90 to calcium ratio versus age by year of collection

Table 1. Strontium-90 in human bones by year of death and age in the United States

Age (years)	Strontium-90 to calcium ratio (pCi/g)				
	1962	1963	1964	1965	1966
0[a]	[b] 2.28 (16) 1.26–4.13	1.04 (3) 1.01–2.00	2.34 (9) 1.24–4.46	3.08 (38) 1.30–7.30	3.56 (6) 2.13–5.97
1	4.17 (9) 2.24–7.76	4.83 (4) 2.83–8.26	5.20 (9) 3.63–7.45	4.32 (13) 3.16–5.91	4.07 (13) 3.25–5.08
2	3.81 (11) 2.48–5.84	5.60 (9) 3.32–9.45	5.16 (19) 3.31–8.04	5.14 (19) 3.68–7.18	3.87 (16) 2.53–5.80
3	3.13 (8) 2.33–4.21	5.14 (11) 2.95–8.07	4.62 (20) 3.21–6.64	4.56 (15) 3.77–5.51	4.09 (16) 2.75–5.95
4	2.70 (10) 2.01–3.61	4.25 (16) 2.72–6.64	4.09 (17) 2.77–6.05	3.24 (14) 2.50–4.21	3.06 (15) 2.12–4.39
0–4	3.04 (46) 1.79–5.16	4.28 (44) 2.35–7.82	4.25 (66) 2.62–6.91	3.94 (80) 2.28–6.81	3.70 (67) 2.54–5.37
5–9	2.74 (38) 1.44–5.22	4.00 (42) 2.72–5.80	3.70 (64) 2.52–5.43	3.06 (36) 2.12–4.42	2.69 (60) 1.97–3.67
10–14	2.15 (39) 1.47–3.16	2.86 (66) 1.88–4.35	3.13 (56) 2.13–4.61	2.75 (63) 1.97–3.84	2.59 (87) 1.39–3.55
15–19	2.23 (30) 1.50–3.32	2.65 (74) 1.85–3.79	2.83 (58) 1.86–4.31	2.39 (64) 1.80–3.17	2.34 (76) 1.60–3.42
20–24	1.84 (29) 1.38–2.44	2.10 (61) 1.47–3.26	2.11 (54) 1.40–3.17	1.84 (69) 1.37–2.49	1.74 (61) 1.32–2.28

[a] Includes age group 0 to 5 months.

[b] Upper left number is the median. The number in parentheses indicates the number of samples. The lower numbers are the minimum and maximum values which embrace 68 percent of the samples in that group.

because of less mineral content and less absorption of available beta-particle energy, resulting in a concentration of 126 pCi/g Ca corresponding to 0.17 rad/a.

The highest single value measured for an individual in the 0-4 age group in 1962 was 10.8 pCi ^{90}Sr/g Ca. In 1963, the highest single value was 9.95 pCi ^{90}Sr/g Ca for this age group. The value was 14.6 pCi ^{90}Sr/g Ca for 1964. The values for 1965 and 1966 were 11.7 and 9.6 pCi ^{90}Sr/g Ca. These data for individuals, with the single exception in 1964, were within the guides corresponding to Range I. The average values within the five age groups for all years (1962-1966) also reveal that the Range I was not exceeded. Because of unavoidable deficienceis in the sampling programs, especially lack of samples in certain regions for some of the years, no definite inferences on population average values could be made.

The percentile distribution of the samples by strontium-90 to calcium ratio and year are as follows: In 1962, 84 percent of the samples analyzed contained 3.0 pCi ^{90}Sr/g Ca or less. In 1963, 85 percent of the samples were equal to or less than 4.0 pCi ^{90}Sr/g Ca, and in 1964, the 85 percent value had risen to 5.0 pCi ^{90}Sr/g Ca. The 85 percent value decreased in 1965 to 4.0 pCi ^{90}Sr/g Ca and decreased again to 3.5 pCi ^{90}Sr/g Ca in 1966. These data are in agreement with the previously observed trends. A log probability plot for the year 1966 is shown in figure 3 by age groups. These data are normally distributed as in previous years (*2-4*) and as originally reported by Kulp (*5*) for biological materials. Figure 4 shows a histogram of the frequency distribution for the year 1966, showing a slightly positive skewness.

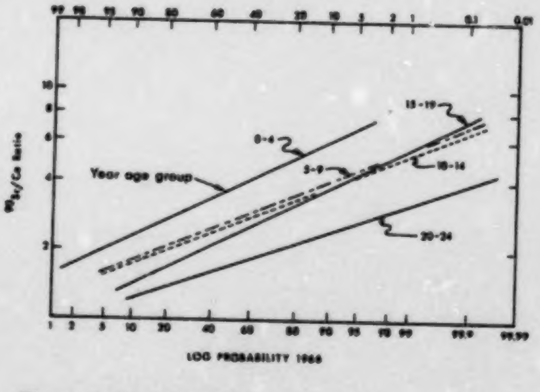

Figure 3. Log probability plot of strontium-90 to calcium ratios by age group for 1966

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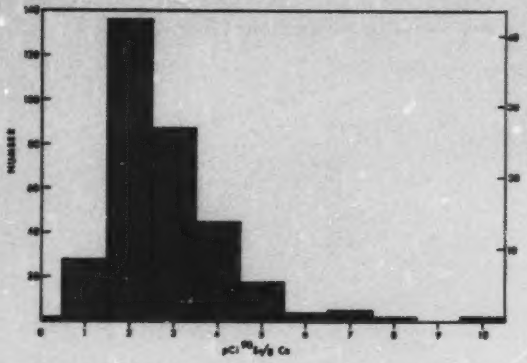

Figure 4. Frequency distribution strontium-90 to calcium ratios for 1966

Summary

From 1962 through 1966, over 1,600 human bone specimens were analyzed. The specimens are grouped and analyzed according to age and area of residence. A review of the data shows that peak strontium-90 levels occurred in most age groups during the years 1963 and 1964. The strontium-90 to calcium ratios began decreasing after 1964 and in 1966 approached those of 1962. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, December 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

> Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service) - 5 sampling stations
>
> Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare) - 16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively.) The contents of both

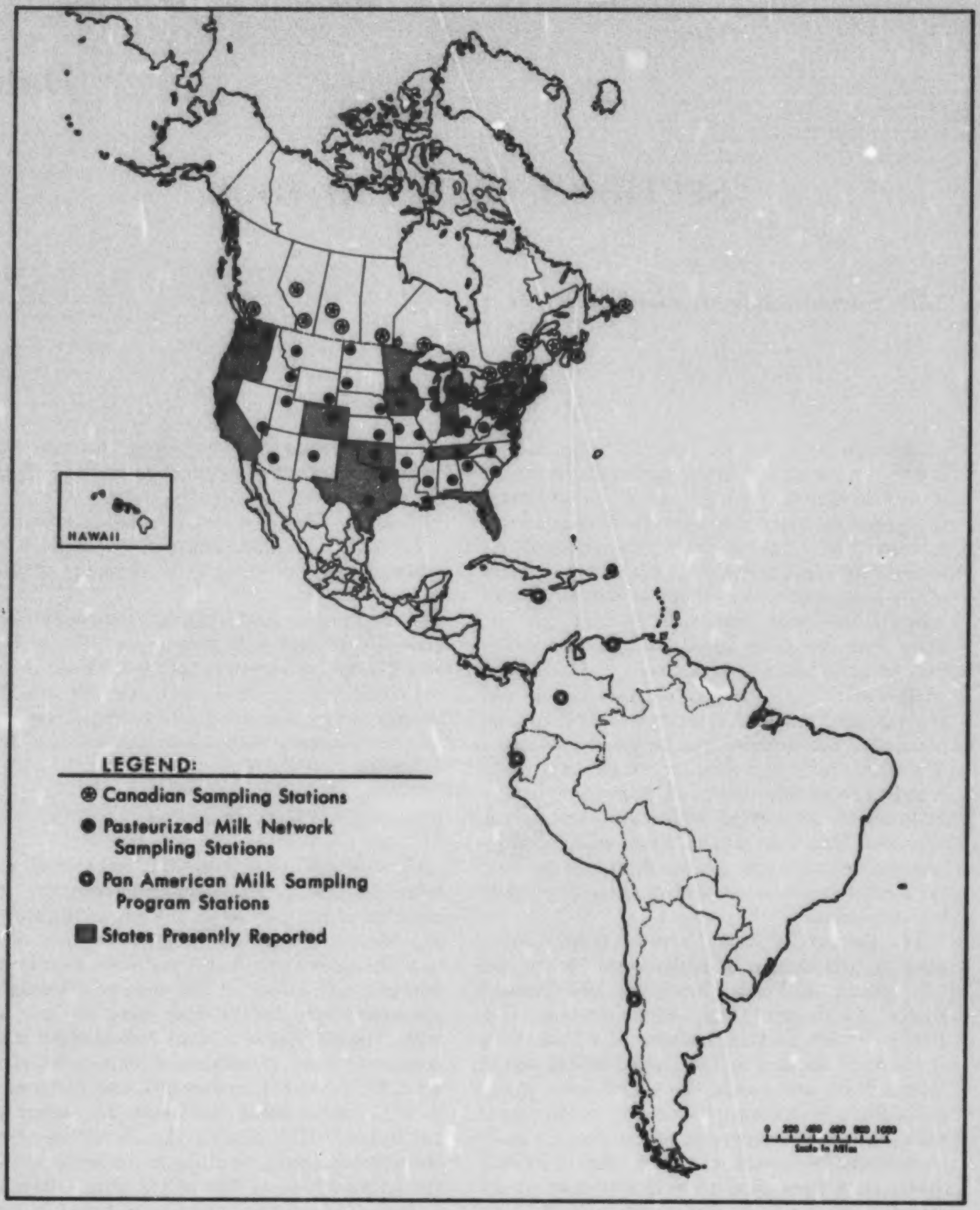
HAWAII
LEGEND:
⊗ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July-September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137 and barium-140. Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 14 participated in the experiment.

The iodine-131 and cesium-137 results show much improvement over previous tests. Barium-140 results also look good which is encouraging, since this is the first time barium-140 was analyzed for this type of experiment. However, strontium-89 and strontium-90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular

14

attention w[illegible] strontium-90 and cesium-137 in tha[illegible]

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,000	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age: cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maxi-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

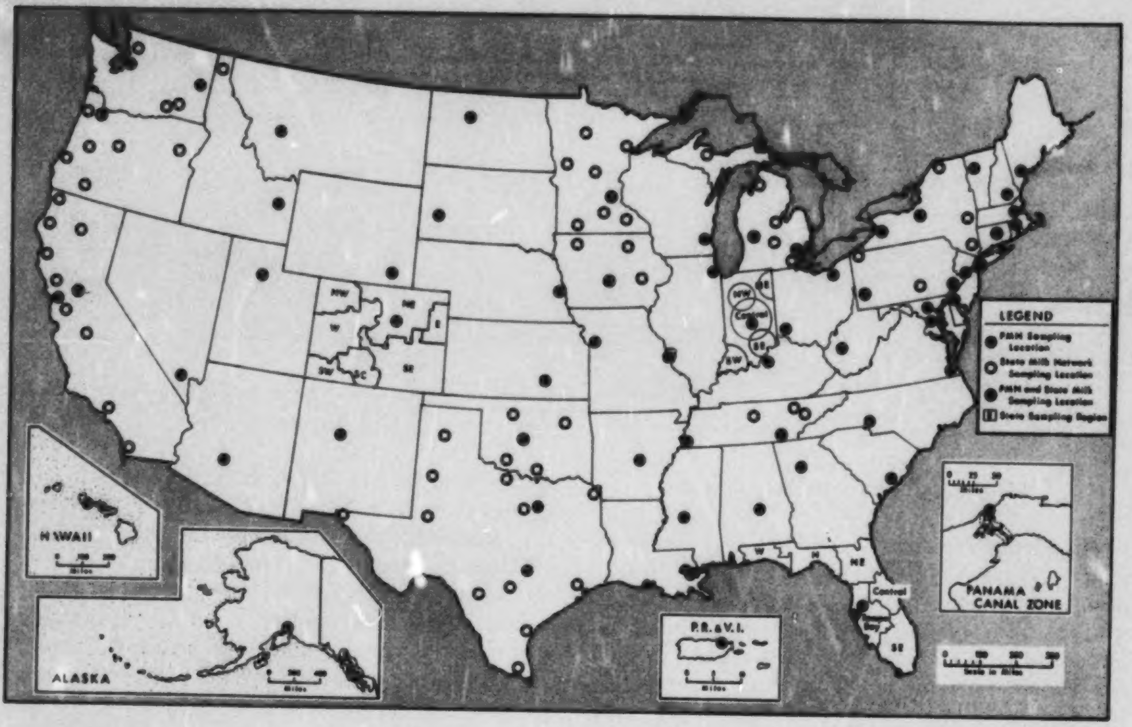

Figure 2. State and PMN milk sampling locations in the United States

mum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for December 1969 and the 12-month period, January 1969 to December 1969. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels

Table 3. Concentration of radionuclides in milk for December 1969 and 12-month period, January 1969 through December 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	7	0 (4)	0	10 (4)	10
Alaska:	Palmer[c]	P	4	6	0 (5)	0	10 (5)	6
Ariz:	Phoenix[c]	P	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	11	17	0 (5)	0	19 (5)	18
Calif:	Sacramento[c]	P	0	1	0 (3)	0	0 (3)	0
	San Francisco[c]	P	0	2	0 (5)	0	0 (5)	0
	Del Norte	P	19	19	0	0	16	20
	Fresno	P	2	2	0	0	3	5
	Humboldt	P	5	5	0	0	6	8
	Los Angeles	P	2	2	0	0	6	3
	Mendocino	P	2	4	0	0	3	5
	Sacramento	P	1	3	0	0	2	5
	San Diego	P	1	2	0	0	0	3
	Santa Clara	P	1	2	0	0	2	5
	Shasta	P	3	3	0	0	2	7
	Sonoma	P	2	3	0	0	0	5
Colo:	Denver[c]	P	5	5	0	0	0 (4)	1
	West	R	NS		NS	(e)	NS	(e)
	Northeast	R	NS		NS	(e)	NS	(e)
	East	R	NS		NS	(e)	NS	(e)
	Southeast	R	NS		NS	(e)	NS	(e)
	South Central	R	NS		NS	(e)	NS	(e)
	Southwest	R	NS		NS	(e)	NS	(e)
	Northwest	R	NS		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	7	7	0 (4)	0	9 (4)	11
	Central	P	6	7	0 (4)	0	11 (4)	6
Del:	Wilmington[c]	P	7	9	0 (4)	0	4 (4)	6
D.C:	Washington[c]	P	8	8	0 (4)	0	3 (4)	4
Fla:	Tampa[c]	P	5	6	0 (3)	0	50 (3)	35
	West	R	NA	12	0	0	14	25
	North	R	9	13	0	0	0	26
	Northeast	R	6	8	0	0	18	38
	Central	R	8	8	0	0	45	57
	Tampa Bay area	R	6	8	0	0	48	57
	Southeast	R	9	8	0	0	47	90
Ga:	Atlanta[c]	P	9	10	0 (5)	0	18 (5)	19
Hawaii:	Honolulu[c]	P	3 (5)	2	0 (5)	0	0 (5)	0
Idaho:	Idaho Falls[c]	P	5	5	0 (5)	0	2 (5)	5
Ill:	Chicago[c]	P	8	7	0 (5)	0	5 (5)	9
Ind:	Indianapolis[c]	P	6	8	0 (5)	0	7 (5)	6
	Northeast	P	11	10	0	0	15	10
	Southeast	P	10	8	0	0	15	12
	Central	P	8	8	0	0	10	10
	Southwest	P	10	9	0	0	10	12
	Northwest	P	9	10	0	0	20	17
Iowa:	Des Moines[c]	P	7	6	0 (5)	0	0 (5)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	7	7	0 (5)	0	0 (5)	1
Ky:	Louisville[c]	P	5	9	0 (5)	0	0 (5)	5
La:	New Orleans[c]	P	22	16	0 (3)	0	15 (3)	19
Maine:	Portland[c]	P	8	12	0 (5)	0	20 (5)	23
Md:	Baltimore[c]	P	6	8	0 (5)	0	13 (5)	7
Mass:	Boston[c]	P	11	11	0 (5)	0	19 (5)	22
Mich:	Detroit[c]	P	6	8	0 (5)	0	5 (5)	9
	Grand Rapids[c]	P	8	10	0 (5)	0	10 (5)	13
	Bay City	P	NA	7	(e) (2)	(e)	0 (2)	7
	Charlevoix	P	NA	9	(e) (5)	(e)	14 (5)	18
	Detroit	P	NA	6	(e) (5)	(e)	5 (5)	6
	Grand Rapids	P	NA	8	(e) (5)	(e)	12 (5)	12
	Lansing	P	NA	6	(e) (2)	(e)	14 (2)	12
	Marquette	P	NA	10	(e) (3)	(e)	21 (3)	27
	Monroe	P	NA	5	(e) (2)	(e)	0 (2)	2
	South Haven	P	NA	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	9	10	0 (5)	0	5 (5)	9
	Bemidji	P	13	17	0	0	23	24
	Mankato	P	6	8	0	0	14	10
	Rochester	P	8	8	0	0	12	9
	Duluth	P	16	17	0	0	23	24
	Worthington	P	6	8	0	0	0	9
	Minneapolis	P	9	12	0	0	14	11
	Fergus Falls	P	9	10	0	0	11	11
	Little Falls	P	8	10	0	0	12	13
Miss:	Jackson[c]	P	9	12	0 (5)	0	12 (5)	14
Mo:	Kansas City[c]	P	8	7	0 (5)	0	0 (5)	1
	St. Louis[c]	P	8	8	0 (4)	0	0 (4)	2
Mont:	Helena[c]	P	6	5	0 (4)	0	5 (4)	5
Nebr:	Omaha[c]	P	8	6	0 (4)	0	0 (4)	1
Nev:	Las Vegas[c]	P	0	1	0 (5)	0	0 (5)	0

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for December 1969 and 12-month period, January 1969 through December 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H:	Manchester[c]	P	7	8	0 (5)	0	10 (5)	20
N.J:	Trenton[c]	P	7	9	0 (5)	0	5 (5)	7
N.Mex:	Albuquerque[c]	P	5	2	0 (5)	0	0 (5)	0
N.Y:	Buffalo[c]	P	7	7	0 (5)	0	4 (5)	9
	New York City[c]	P	9	10	0 (5)	0	12 (5)	12
	Syracuse[c]	P	7	7	0 (4)	0	8 (4)	9
	Albany	P	(e) (3)	6	0 (4)	0	(e) (4)	(e)
	Buffalo	P	(e)	(e)	0	0	(e)	(e)
	Massena	P	7 (2)	8	0 (2)	0	(e) (2)	(e)
	Newburg	P	(e)	9	0	0	(e)	(e)
	New York City	P	9 (3)	9	0 (3)	0	(e) (3)	(e)
	Syracuse	P	(e)	6	0	0	(e)	(e)
N.C:	Charlotte[c]	P	11	13	0 (5)	0	15 (5)	12
N.Dak:	Minot[c]	P	10	10	0 (5)	0	17 (5)	13
Ohio:	Cincinnati[c]	P	9	8	0 (5)	0	5 (5)	3
	Cleveland[c]	P	9	9	0 (4)	0	0 (4)	6
Okla:	Oklahoma City[c]	P	3	7	0 (3)	0	4 (3)	8
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	3	6	0 (4)	0	6 (4)	6
	Baker	P	NA	2	(e)	(e)	(e)	8
	Coos Bay	P	NA	5	(e)	(e)	22	12
	Eugene	P	NA	4	(e)	(e)	19	8
	Medford	P	NA	2	(e)	(e)	(e)	17
	Portland composite	P	NA	3	(e)	(e)	(e) (4)	6
	Portland local	P	NA	5	(e)	(e)	(e) (4)	9
	Redmond	P	NA	1	(e)	(e)	15	5
	Tillamook	P	NA	6	(e)	(e)	(e)	16
Pa:	Philadelphia[c]	P	9	9	0 (3)	0	0 (3)	4
	Pittsburgh[c]	P	11	12	0 (5)	0	6 (5)	8
	Dauphin	P	5	6	0	1	0	14
	Erie	P	8	10	0	5	33	21
	Philadelphia	P	6	7	18	5	19	10
	Pittsburgh	P	11	10	0	2	26	18
R.I:	Providence[c]	P	8	9	0 (5)	0	11 (5)	16
S.C:	Charleston[c]	P	10	11	0 (4)	0	20 (4)	23
S.Dak:	Rapid City[c]	P	8	8	0 (5)	0	4 (5)	5
Tenn:	Chattanooga[c]	P	8	10	0 (5)	0	10 (5)	13
	Memphis[c]	P	8	8	0 (5)	0	5 (5)	5
	Chattanooga	P	12	13	0 (2)	0	17 (2)	15
	Clinton	P	13	15	0	0	14	14
	Knoxville	P	6	10	0 (2)	0	8 (2)	5
	Nashville	P	NS	9	NS	0	NS	6
Tex:	Austin[c]	P	0	2	0 (4)	0	0 (4)	4
	Dallas[c]	P	3	6	0 (5)	0	2 (5)	6
	Amarillo	R	3	4	0	0	0	0
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	NS	5	NS	0	NS	2
	Harlingen	R	4	3	0	0	0	0
	Houston	R	NS	6	NS	0	NS	11
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	5	4	0	0	0	0
	Texarkana	R	NS	11	NS	0	NS	15
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	6	NS	0	NS	8
Utah:	Salt Lake City[c]	P	8	4	0 (5)	0	0 (5)	4
Vt:	Burlington[c]	P	7	8	0 (5)	0	14 (5)	14
Va:	Norfolk[c]	P	10	10	0 (4)	0	2 (4)	8
Wash:	Seattle[c]	P	5	7	0 (5)	0	5 (5)	12
	Spokane[c]	P	7	7	0 (5)	0	6 (5)	4
	Benton County	R	NS	1	NS		NS	4
	Franklin County	R	3	2	NA		NA	
	Sandpoint, Idaho	R	5	11	NA		NA	
	Skagit County	R	3	7	NA		NA	
W.Va:	Charleston[c]	P	6	9	0 (3)	0	0 (3)	7
Wisc:	Milwaukee[c]	P	7	7	0 (4)	0	10 (4)	11
Wyo:	Laramie[c]	P	5	5	0 (5)	0	0 (5)	5
CANADA:								
Alberta:	Calgary	P	7	8	(d)		16	15
	Edmonton	P	7	7	(d)		17	13
British Columbia:	Vancouver	P	8	11	(d)		37	32
Manitoba:	Winnipeg	P	6	8	(d)		29	25
New Brunswick:	Fredericton	P	15	13	(d)		13	16
Newfoundland:	St. Johns	P	15	17	(d)		21	34

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for December 1969 and 12-month period, January 1969 through December 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Nova Scotia:	Halifax	P	10	10	(d)		16	19
Ontario:	Ft. William	P	11	15	(d)		25	30
	Ottawa	P	8	8	(d)		10	14
	Saulte Ste. Marie	P	14	15	(d)		26	30
	Toronto	P	5	5	(d)		9	10
	Windsor	P	5	5	(d)		8	11
Quebec:	Montreal	P	7	8	(d)		17	17
	Quebec	P	10	11	(d)		21	25
Saskatchewan:	Regina	P	6	7	(d)		13	12
	Saskatoon	P	6	8	(d)		9	12
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	1	0	0	0	1
Chile:	Santiago	P	0	0	0	0	10	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	NS		NS		NS	
Venezuela:	Caracas	P	4	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	1	0 (5)	0	9 (5)	11
Puerto Rico:	San Juan[c]	P	4	3	0 (5)	0	4 (5)	7
PMN network average[f]			7	7	0	0	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote c.
NA, no analysis.
NS, no sample collected.

at the great majority of the stations for December 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 was detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for the month of December 1969, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif.) representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 50 pCi/liter in the United States for the month of December 1969, and the highest 12-month average was 90 pCi/liter (Southeast Florida) representing 2.5 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level, except Philadelphia, Pa. (State)—18 pCi/liter for the month of December 1969.

Table 4. Monthly average of strontium-89 in milk December 1969

Sampling location	Radionuclide concentration (pCi/liter)
Calif: Del Norte (State)	6
N.Dak: Minot (PMN)	7
Tenn: Chattanooga (State)	8
Clinton (State)	7
Tex: Dallas (PMN)	6

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Health
Radiological and Occupational
Health Section
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Radionuclides in Institutional Diet Samples, *PHS*	April–June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August–December 1968	December 1969
Connecticut Standard Diet	July–December 1968 and January–June 1969	February 1970

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activites recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Coast Guard	January 1968–June 1969	February 1970
Colorado River Basin	1967	December 1968
Florida	1968	March 1970
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications to changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Plutonium in Airborne Particulates	July–September 1968	February 1970

1. Radiation Alert Network
December 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during December 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

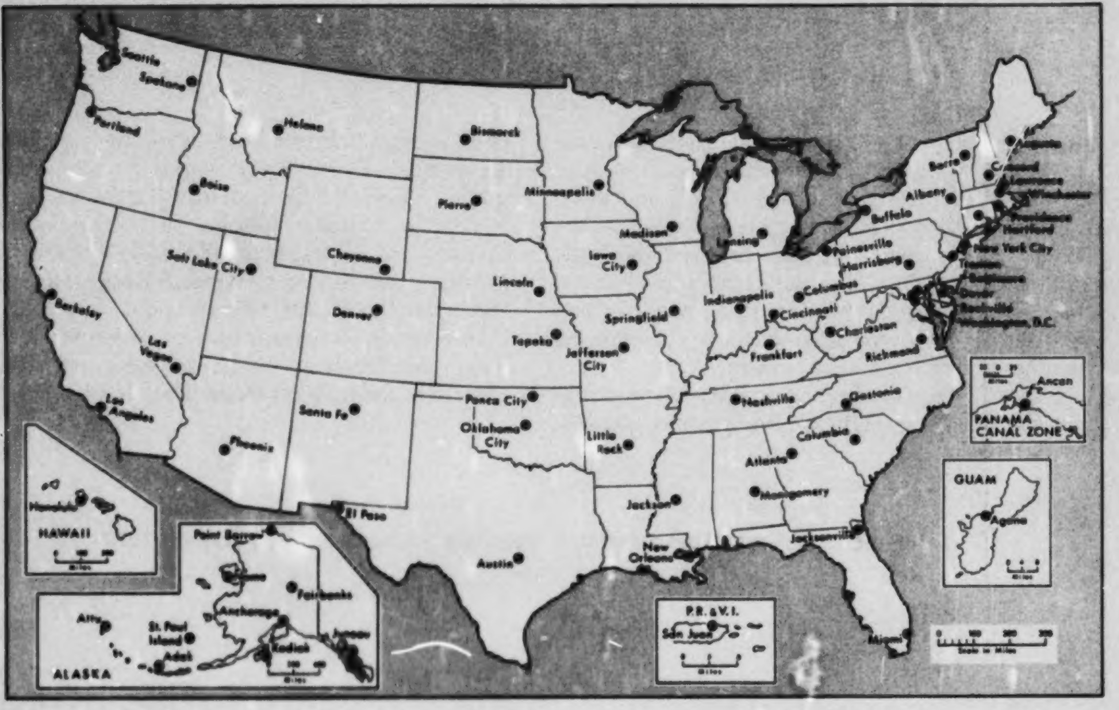
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Salt Lake City
Cheyenne
Berkeley
Lincoln
Denver
Las Vegas
Topeka
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
El Paso
Austin
Madison
Lansing
Iowa City
Springfield
Jefferson City
Indianapolis
Cincinnati
Columbus
Frankfort
Charleston
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Richmond
Nashville
Gastonia
Little Rock
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Juneau
Kodiak
Attu
St. Paul Island
Adak
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
			Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Field estimation of deposition		
									Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	6	0	2	Dec 69	3	78	3	78	16
Alaska:	Adak	11	1	1	1	Dec 69	(c)				
	Anchorage	20	0	0	0	Aug 69	(c)				
	Attu Island	11	0	0	0	Jan 70	(c)				
	Fairbanks	20	0	0	0	Sept 69	1	3	1	3	1
	Juneau	16	2	0	1	Oct 69	9	204	9	204	0
	Kodiak	9	0	0	0	Nov 69	(c)				
	Nome	25	2	0	1	Mar 70	(c)				
	Point Barrow	(b)				Feb 70	(c)				
	St. Paul Island	(b)				April 70	(c)				
Ariz:	Phoenix	19	22	3	9	Oct 69	(c)				
Ark:	Little Rock	5	3	0	1	Aug 69	(c)				
Calif:	Berkeley	21	2	0	1	Nov 69	4	37	4	37	0
	Los Angeles	21	5	0	2	Mar 70	(c)				
C.Z:	Ancon	14	1	0	0	Nov 69	(c)				
Colo:	Denver	23	7	0	3	Nov 69	2	7	(d)		
Conn:	Hartford	21	0	0	0	Sept 69	9	133	9	133	0
Del:	Dover	19	1	0	0	July 69	(c)				
D.C:	Washington	29	7	0	1	Feb 70	1	1	(e)		
Fla:	Jacksonville	22	2	0	1	Aug 69	4	90	4	90	0
	Miami	16	0	0	0	Sept 69	4	39	4	39	0
Ga:	Atlanta	19	1	1	1	Apr 70	1	56	1	56	23
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	26	1	0	1	Jan 70	2	27	(d)		
Idaho:	Boise	21	7	0	2	Jan 70	8	45	8	45	3
Ill:	Springfield	20	3	0	2	Feb 70	(c)				
Ind:	Indianapolis	(b)				Apr 70	(c)				
Iowa:	Iowa City	18	3	0	1	Nov 69	4	42	4	42	0
Kans:	Topeka	20	5	0	2	Aug 69	3	25	3	25	1
Ky:	Frankfort	(b)				Feb 70	(c)				
La:	New Orleans	18	2	0	0	Feb 70	5	168	(d)		
Maine:	Augusta	21	1	0	0	Mar 70	11	282	11	282	0
Md:	Baltimore	22	1	0	0	Sept 69	5	50	5	50	30
	Rockville	10	1	0	0	Jan 70	(c)				
Mass:	Lawrence	20	0	0	0	Nov 69	6	225	6	225	0
	Winchester	21	0	0	0	Dec 69	9	169	9	169	0
Mich:	Lansing	22	1	0	0	Jan 70	(c)				
Minn:	Minneapolis	22	10	0	1	July 69	7	69	7	60	1
Miss:	Jackson	16	1	0	0	Mar 70	3	151	3	151	0
Mo:	Jefferson City	21	2	0	1	Apr 70	7	46	7	46	0
Mont:	Helena	75	3	0	2	Dec 69	1	4	1	4	0
Nebr:	Lincoln	10	6	0	2	Apr 70	2	28	2	28	10
Nev:	Las Vegas	15	2	0	1	Sept 69	(c)				
N.H:	Concord	(b)				Feb 70	(c)				
N.J:	Trenton	22	1	0	0	Mar 70	9	142	9	142	1
N.Mex:	Santa Fe	12	2	0	1	Dec 69	2	31	2	31	2
N.Y:	Albany	13	0	0	0	Apr 70	7	53	7	53	22
	Buffalo	19	1	0	0	Nov 69	(c)				
	New York City	22	2	0	0	Dec 69	(c)				
N.C:	Gastonia	16	12	1	4	Nov 69	3	31	(d)		
N.Dak:	Bismarck	20	4	0	2	Feb 70	5	20	5	20	2
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	4	1	0	0	Mar 70	1	10	(e)		
	Painesville	23	1	0	1	Sept 69	9	706	9	706	7
Okla:	Oklahoma City	10	5	0	2	Jan 70	1	39	1	30	1
	Ponca City	20	15	0	2	Sept 69	5	128	4	126	0
Ore:	Portland	15	1	0	0	Apr 70	12	86	12	86	7
Pa:	Harrisburg	16	0	0	0	Apr 70	1	8	1	8	1
P.R:	San Juan	(b)				Mar 70	(c)				
R.I:	Providence	15	1	0	0	Jan 70	5	121	5	121	12
S.C:	Columbia	14	6	0	1	Dec 69	3	63	3	63	1
S.Dak:	Pierre	6	6	2	4	Oct 69	(c)				
Tenn:	Nashville	15	2	0	1	Jan 70	6	121	6	121	5
Tex:	Austin	12	5	1	3	July 69	1	45	(d)		
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	29	6	0	2	Mar 70	8	34	8	34	4
Vt:	Barre	16	1	0	0	Aug 69	9	54	9	54	8
Va:	Richmond	20	1	0	0	Aug 69	5	143	5	143	20
Wash:	Seattle	1	0	0	0	Aug 69	13	125	(d)		
	Spokane	16	1	0	1	July 69	(c)				
W.Va:	Charleston	21	2	0	1	Dec 69	8	112	8	112	13
Wisc:	Madison	20	4	0	1	Aug 69	4	35	4	35	6
Wyo:	Cheyenne	18	8	0	2	Sept 69	1	3	1	3	1
Network summary		1,172	22	0	1		6	110	5	99	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] No report received. (Air samples received without field estimate data are not considered by the data program.)

[c] No precipitation sample collected.

[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

[e] Samples were collected but no field estimates were received.

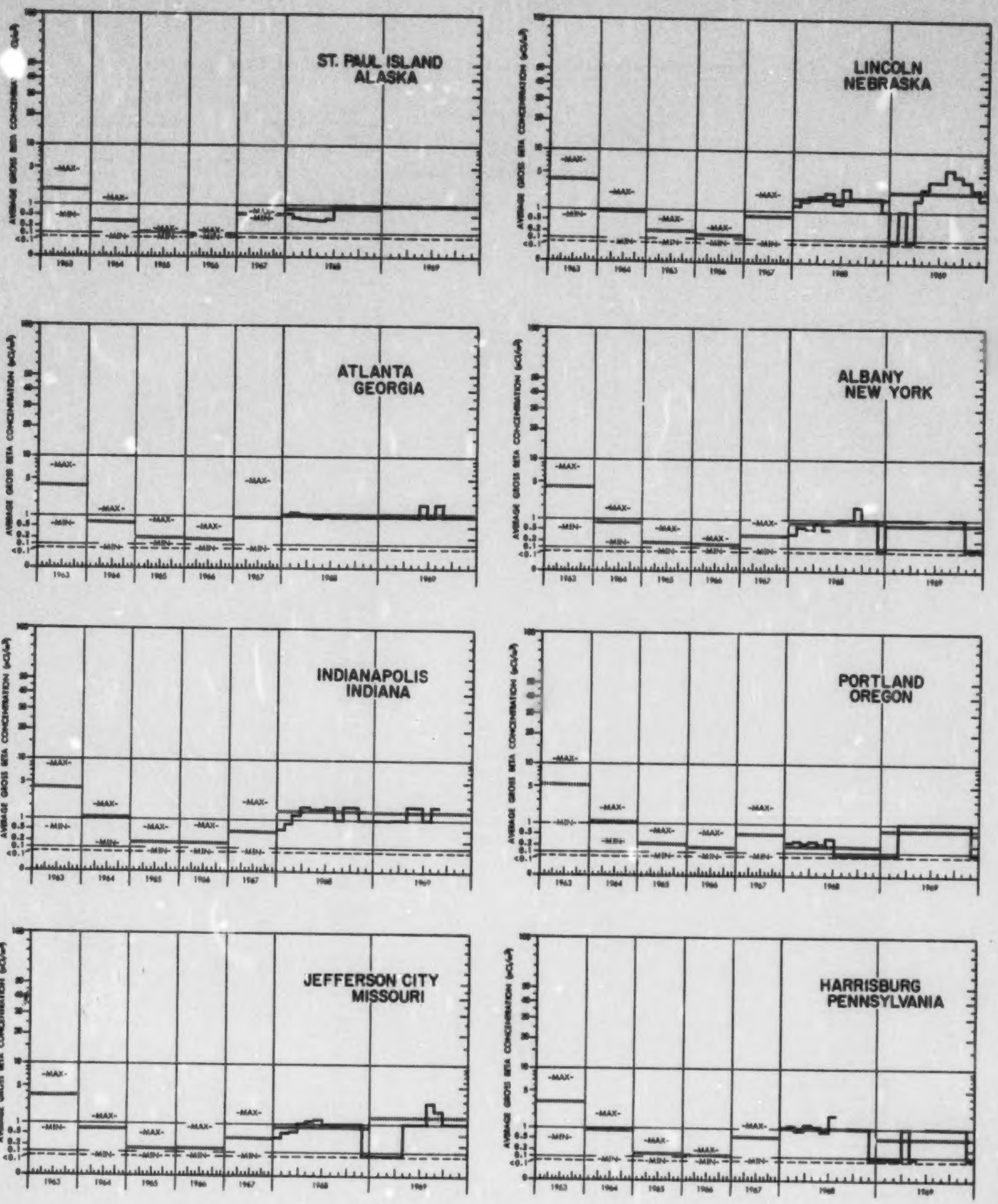

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–December 1969

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2. Canadian Air and Precipitation Monitoring Program[1], December 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for December 1969 are presented in table 2.

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.1	0.0	0.1	NS	NS
Coral Harbour	28	.1	.0	.1	NS	NS
Edmonton	31	.1	.0	.1	42	0.6
Ft. Churchill	28	.1	.0	.1	20	.2
Ft. William	31	.1	.0	.1	14	2.3
Fredericton	30	.1	.0	.0	7	1.0
Goose Bay	31	.1	.0	.0	15	2.7
Halifax	31	.1	.0	.1	8	.3
Inuvik	25	.1	.0	.0	6	.7
Montreal	31	.1	.0	.1	10	.3
Moosonee	31	.1	.0	.1	26	2.0
Ottawa	31	.1	.0	.1	20	2.0
Quebec	30	.1	.0	.0	42	.4
Regina	31	.1	.0	.1	46	.2
Resolute	30	.1	.0	.1	24	3.6
St. John's, Nfld.	31	.1	.0	.0	48	.6
Saskatoon	30	.1	.0	.0	38	1.4
Saulte Ste Marie	31	.1	.0	.1	27	1.2
Toronto	31	.1	.0	.1	15	.9
Vancouver	31	.1	.0	.0	23	3.3
Whitehorse	31	.1	.0	.0	30	.3
Windsor	31	.1	.0	.1	22	1.2
Winnipeg	31	.1	.0	.1	13	.2
Yellowknife	30	.1	.0	.1	38	.5
Network summary	727	0.1	0.0	0.1	24	1.2

NS, no sample.

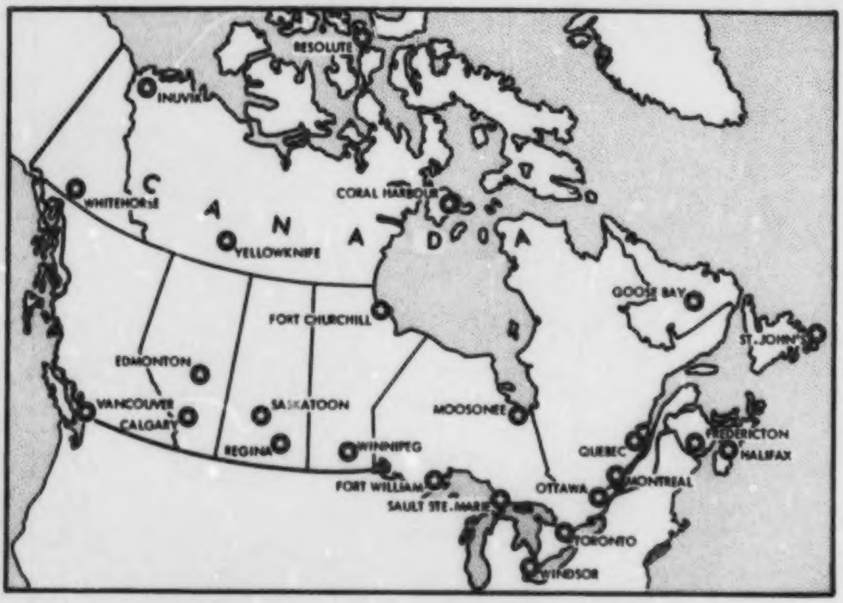
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program September and October 1969

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency, 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during September and October 1969 are presented in tables 3 and 4.

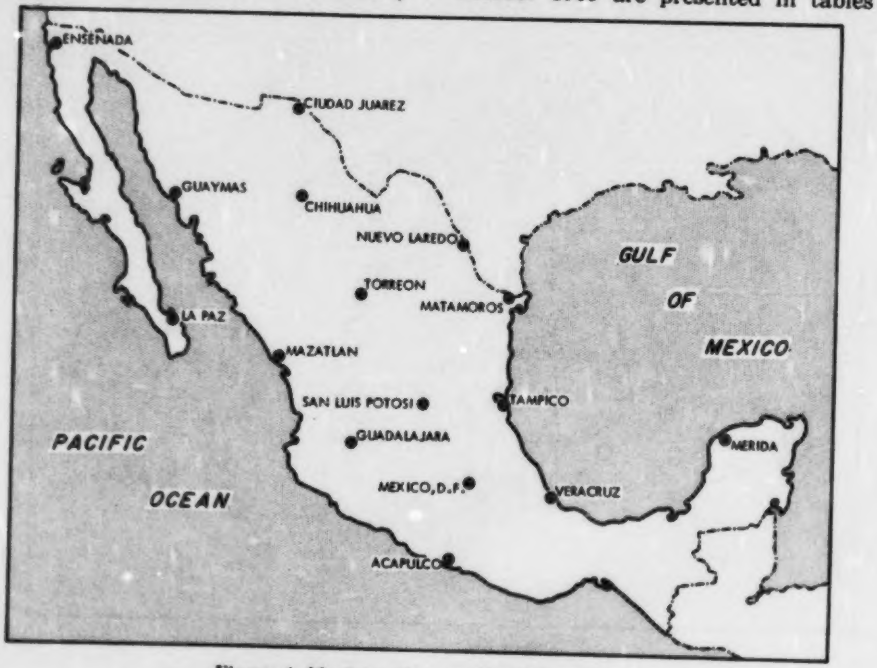

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	11	0.3	0.1	0.2
Ciudad Juarez	3	.2	.1	.1
Ensenada	5	.2	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	15	.2	.1	.1
México, D.F.	10	.2	.1	.1
Nuevo Laredo	6	.3	.1	.2
San Luis Potosí	NS			
Tampico	NS			
Torreon	11	.2	.1	.1
Veracruz	2	.1	.1	.1

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, October 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	2	0.1	<0.1	<0.1
Chihuahua	16	.3	<.1	.2
Ciudad Juarez	3	.2	.1	.1
Ensenada	12	.5	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	1	.1	.1	.1
Matamoros	NS			
Mazatlan	NS			
Mérida	11	.2	.1	.1
México, D.F.	5	.1	<.1	<.1
Nuevo Laredo	7	.4	.2	.3
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.6	.1	.2
Veracruz	NS			

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program December 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The December 1969 air monitoring results from the participating countries are given in table 5.

Table 5. Summary of gross beta radioactivity in Pan American surface air, December 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	21	0.16	0.05	0.09
Bolivia:	La Paz	10	.15	.01	.08
Chile:	Santiago	30	.17	.03	.09
Colombia:	Bogota	20	.05	.00	.02
Ecuador:	Cuenca	NS			
	Guayaquil	NS			
	Quito	1	.01	.01	.01
Guyana:	Georgetown	NS			
Jamaica:	Kingston	13	.11	.01	.06
Peru:	Lima	NS			
Venezuela:	Caracas	15	.10	.00	.03
West Indies:	Trinidad	16	.04	.01	.02
Pan American summary		126	0.17	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

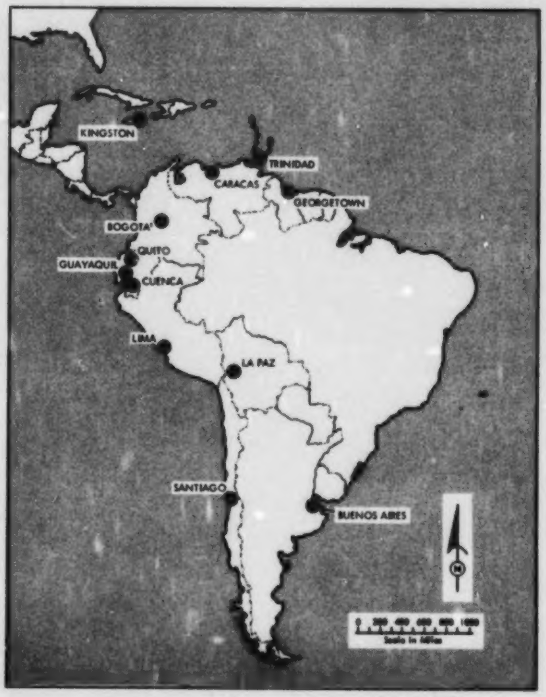

Figure 5. Pan American Air Sampling Program stations

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Lawrence Radiation Laboratory, Neutron Devices Department, Paducah Plant, and Portsmouth Area Gaseous Diffusion Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory[2]
January–June 1969

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

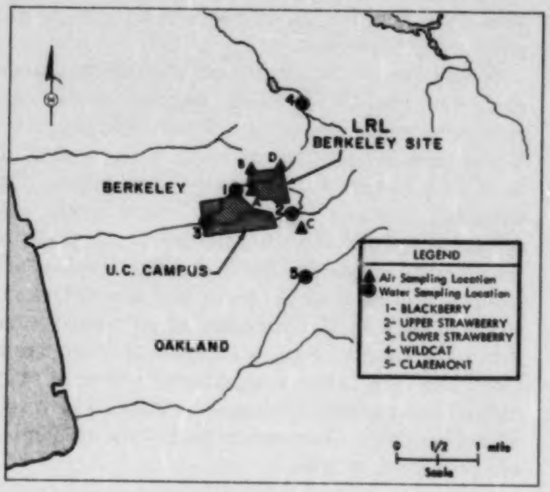

Figure 1. Environmental sampling locations at the Berkeley Site, Lawrence Radiation Laboratory

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

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[2] Summarized from "Results of Environmental Radioactivity Sampling Program, January–June 1969" Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantity released from these stacks during January-June 1969 was 64 μCi of beta-particle emitters. No alpha radioactivity was detected. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 1 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property in the direction of populated area. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

Table 1. Atmospheric monitoring, LRL Berkeley Site January–June 1969

Sampling locations (number of locations)	Number of samples	Average concenrration (pCi/m^3)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	253	0.000	<0.005	0.14	0.62
Perimeter (4)	100	.000	<.005	.14	.47

At each of these environmental stations rain or dry fallout is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 2. Total deposition, LRL Berkeley Site January–June 1969

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m^2)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (9)	54	0.03	0.08	9.57	11.31
Perimeter (4)	24	.06	.22	8.92	10.77

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Small quantities of radioisotopes now and then are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha-plus-beta radioactivity) in sewage is only 16 percent of the standard for drinking water and therefore does not constitute an exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium-40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in table 3. Two nearby offsite streams are also sampled to provide a comparison. All concentrations are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at

Table 3. Water monitoring, LRL Berkeley site January–June 1969

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Surface water:					
Onsite streams					
Blackberry	26	0.35	2.2	4.60	41.3
Lower Strawberry	26	.45	1.8	10.66	30.2
Upper Strawberry	26	.29	3.5	3.37	9.0
Summary	78	.36		6.21	
Offsite streams:					
Claremont	26	.58	1.4	2.82	16.3
Wildcat	26	.00	1.6	2.23	9.6
Summary	52	.29		2.52	

several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source. These instruments operate unattended and each can operate for 1 week on its internal battery should external power fail.

Table 4. Beta-gamma and fast neutron surveillance results, Berkeley site, January 1968–June 1969

Station	Total beta-gamma exposure (mrem) (background subtracted)			Total fast neutron exposure[a] (mrem) (background subtracted)		
	Jan–June 1968	July–Dec 1968	Jan–June 1969	Jan–June 1968	July–Dec 1968	Jan–June 1969
A	12.7	5.72	10.9	56.7	56.4	38.80
B	6.1	(b)	4.4	21.4	30.5	26.42
C	8.0	(b)	(b)	4.4	34.5	(b)
D	4.5	1.12	6.1	46.0	53.5	55.07
Shattuck Avenue and Berkeley Way	0.2	(c)	(c)	(c)	(b)	(b)

[a] 2.45 × 10⁷ n/cm² = 1 rem
[b] Background.
[c] Detector not in service.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a 2 1/2 inch thick paraffin lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays. Results are presented in table 4.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in northern California--approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches and the relative humidity is about 30 percent during the summer months and about 40–50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night.

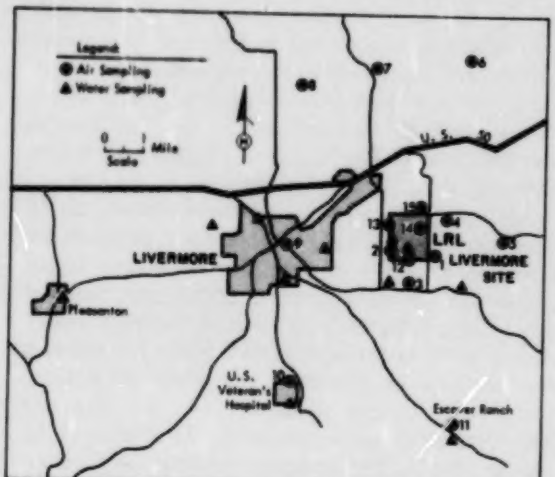

Figure 2. Environmental sampling locations at the Livermore site, LRL.

Agriculture is the principle activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 50,000 are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300. Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to ascertain that radioactivity is not entering the underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton and is the sole supply for ranches in the Livermore and Amador Valleys. Samples were taken at the Livermore Sewage Disposal Plant to establish that liquid effluent from the laboratory is not contributing significant radioactivity to the dried sludge or liquid effluent produced. The dried sludge is used as an agricultural soil conditioner. Some liquid effluent released to the Las Positas Arroyo is used for irrigation of the golf course turf and some agricultural land.

Air samples are collected continuously at 16 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. At no time was any detectable alpha radioactivity observed on the air filters. The average airborne beta radioactivity of 0.06 pCi/m^3 is lower than the 0.1 pCi/m^3 reported for 1968 .The beta radioactivities were below the AEC radiation protection standard of 1 pCi/m^3.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at three offsite locations. The limit of detection for these dosimeters is 10 mR. The three offsite locations had dose recordings of 10 mR for the past 6-month period. At the nine locations in the controlled area, doses of 10 to 54 mR were recorded.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of detection (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of detection, 1.8 pCi/liter to 31 pCi/liter. The average beta radioactivity concentration was 6.5 pCi/liter. The average alpha and beta radioactivity concentrations were below the AEC standard of comparison of 30 pCi/liter.

The average tritium content was at or below the limit of detection (5 nCi/liter), which is well below the standard of comparison of 3 μCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average alpha radioactivity concentration in the sewer effluent ranged between 8 and 19 pCi/liter while the monthly average beta radioactivity varied between 146 and 213 pCi/liter. The AEC standard is 400 pCi/liter. The average tritium content of the effluent was 35 nCi/liter with a maximum of 950 nCi/liter. The AEC standard is 100 μCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity of each sample was less than the limit of detection (1.5 pCi/g). The beta radioactivity fluctuated from the limit of detection, 3.5 pCi/g to 27 pCi/g, averaging 6.8 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley, as determined from surveillance during previous years.

Average radioactivity levels in monthly milk samples amounted to 1.8 pCi/liter of cesium-137 and <5 pCi/liter of cerium-141–144, for the two dairies. The average tritium concentration in milk was at or below the limit of detection (5 nCi/liter).

Vegetation samples were collected during January, March, and May of 1969. The radioactivity of 23 unwashed grass samples and six samples of eucalyptus leaves is presented in table 5. A portion of each sample was freeze dried and the water collected was analyzed for HTO.

Continuous radioactive air sampling is maintained on the effluent from stacks of operations

Table 5. Radioactivity in vegetation, LRL Livermore site January–June 1969

Nuclide	Concentration (pCi/g dry weight)				Limit of detection
	Grass		Eucalyptus leaves		
	Average	Maximum	Average	Maximum	
Beryllium-7	3.28	8.34	0.82	0.89	0.01
Manganese-54	.02	.08	.02	.03	.01
Zirconium-95	.34	.54	.13	.13	.01
Ruthenium-103, -106	.56	1.04	.28	.44	.02
Antimony-125	.11	.21	.17	.30	.02
Cesium-137	.15	.33	.01	.01	.01
Cerium-141, -144	1.70	3.17	.06	1.41	.02
Tritium	[a] 3.5	[a] 21	[a] 11	[a] 24	[a] 3

[a] Concentration for tritium values are shown in nCi/liter.

that are potential sources of radioactive material releases. These facilities include the hot cells, transuranic chemistry, plutonium metallurgy, critical assembly cells, and the reactor building.

The effluent from these buildings passes through absolute filters prior to being exhausted to the atmosphere. The limit of sensitivity for the stack monitoring systems is generally 0.1 pCi/m³ or less. Radioactive particulate material released did not exceed the limit of sensitivity. Gaseous radioactivity released from the reactor, light isotopes building and accelerator facilities was monitored. Considering atmospheric dispersion from the release point to the site boundary, permissible offsite concentrations were not exceeded as a result of stack effluent during the past 6 months.

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 14,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from onsite wells because they are the only readily accessible sources of underground water. Streams in the area are sampled when they contain water. No sample showed an alpha radioactivity concentration above the limit of detection—5.0 pCi/liter. The beta concentration ranged from the limit of detection (1.8 pCi/liter) to 20 pCi/liter, averaging 6.0 pCi/liter. The average tritium concentration was at or below the detectable level of 5 nCi/liter.

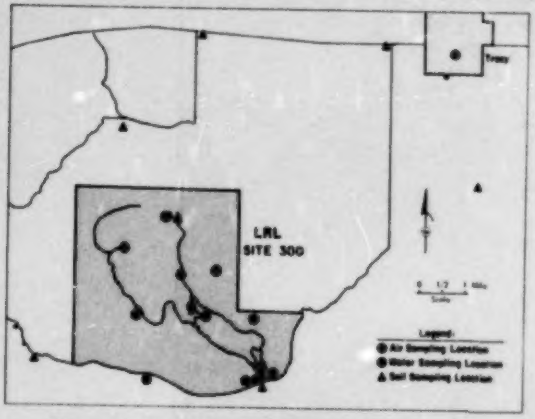

Figure 3. Sampling locations at Site 300, LRL

Soil samples are collected quarterly at nine offsite locations. The alpha radioactivity of each sample was 1.5 pCi/g, the limit of detection. The beta radioactivity ranged from the limit of detection, 3.5 pCi/g to 27 pCi/g, with an average activity of 8.8 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the standards of comparison applicable to activities at the test site, nor did any of the results increase significantly compared to 1968 data. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

2. Neutron Devices Department[3]
January–June 1969

General Electric Company
St. Petersburg, Fla.

The Neutron Devices Department (figure 4) is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate that offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period, eight of 283 samples analyzed showed detectable concentrations of tritium (>90 nCi/liter). The maximum concentration (1.58 μCi/liter, detected on February 10, 1969) represented 53 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system and the plant's water discharges indicate that the tritium concentration in the combined sewer effluent for the first half of 1969 was less than 3.7 percent of the AEC radiation protection standard for continuous nonoccupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data.

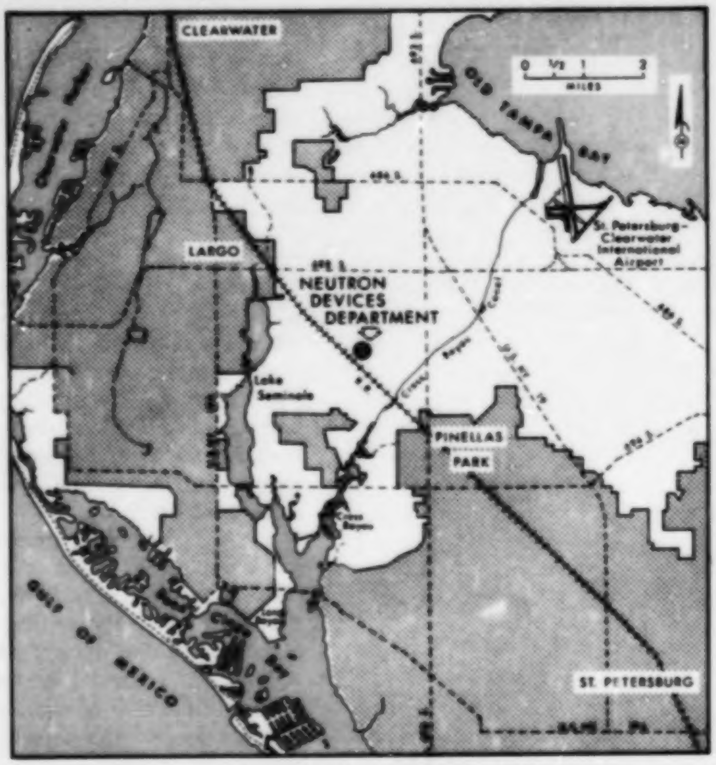

Figure 4. Location of the Neutron Devices Department

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[3] Summarized from "Environmental Monitoring, January 1 through June 30, 1969" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

There were no indications of tritium (>90 nCi/liter) in the 67 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of 12 raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

No detectable amount of tritium gas (>20 μCi/m^3) was found in three samples of air obtained downwind from the exhaust stack at the perimeter of the plant property. No detectable amount of tritium oxide (>5.0 nCi/m^3) was found in four samples of air obtained downwind from the exhaust stack at the perimeter of the plant property.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1968	December 1969
July-December 1968	January 1970

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3. Paducah Plant[4]
January-June 1969

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed, was placed on standby in June of 1964. Parts of the associated uranium metal foundry, usually on standby, are operated infrequently as the need arises. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234 and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery systems at the plant. The environmental monitoring program provides for continuous air sampling at the four stations around the plant perimeter fence and at five stations located approximately 1 mile outside this fence (figure 5). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those contained in Appendix 0524 of the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose

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[4] Summarized from "Environmental Concentrations of Radioactive Materials Near the Paducah Plant—Report for the First Half of 1969."

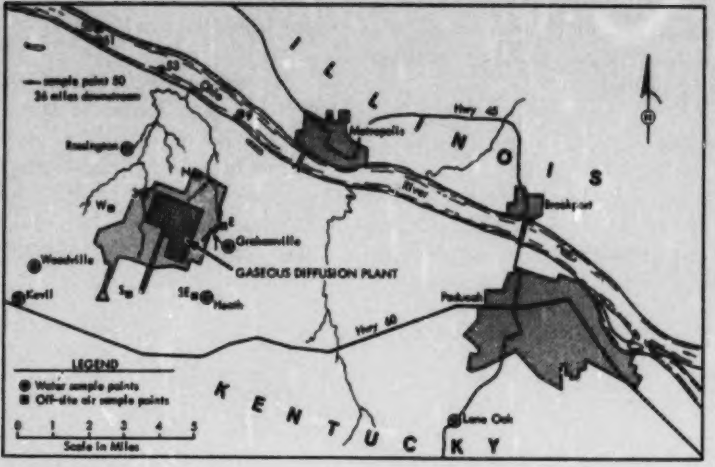

Figure 5. Sampling locations, Paducah Gaseous Diffusion Plant

of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radionuclides in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Table 6. Uranium concentrations in outdoor air samples, Paducah Plant, January–June 1969

Sample location[a]	Number of samples	Uranium alpha radioactivity[b] (pCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	0.24	<0.02	0.04
East	26	.17	<.02	.04
South	26	.05	<.02	<.02
West	26	.05	<.02	<.02
Total	104	0.24	<0.02	0.03
About 1 mile outside plant perimeter fence:				
North	26	0.02	<.02	<.02
East	26	.03	<.02	<.02
South	26	.06	<.02	<.02
West	26	.06	<.02	<.02
Southeast	26	.09	<.02	<.02
Total	130	0.09	<0.02	<0.02

[a] See figure 5.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 by 10⁴ alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 6 through 10.

Table 7. Beta radioactivity in outdoor air samples Paducah Plant, January–June 1969

Sample locations[a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	5.4	<0.1	2.2
East	26	5.9	.2	.6
South	26	.9	<.1	.3
West	26	2.8	.1	.5
Total	104	5.9	<0.1	1.1
About 1 mile outside plant perimeter fence:				
North	26	.9	<.1	.3
East	26	.5	<.1	.2
South	26	.5	<.1	.3
West	26	.7	<.1	.2
Southeast	26	1.0	<.1	.2
Total	130	1.0	<.1	.2

[a] See figure 5.
[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.
[c] The AEC standard, applicable to this table is 1 × 10⁸ pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant.

Table 8. Concentrations of uranium in water Paducah Plant, January–June 1969

Sample location[a]	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou Creek 3	26	20	<1	6
Ohio River 9	5	1	<1	<1
Composite of 50, 51, 52, and 53	5	<1	<1	<1

[a] See figure 5.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 × 10^4 dis/sec.

[c] The minimum detectable uranium in water is 1 pCi/liter.

[d] The AEC standard for natural uranium in water beyond a controlled area is 2 × 10^4 pCi/liter.

Table 9. Concentration of beta-particle emitters in water, Paducah Plant, January–June 1969

Sample locations[a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou Creek 3	26	12,000	<100	900
Ohio River 9	5	200	<100	<100
Composite of 50, 51, 52, and 53	5	<100	<100	<100

[a] See figure 5.

[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.

[c] The AEC standard for the immediate daughter products of uranium in water released to the environs is 2 × 10^4 pCi/liter. An increase in beta activity in water, occurring during February and March, was determined to be due to ^{99}Tc from the recovery operation of cylinder-wash solutions. The AEC standard for ^{99}Tc in water beyond a controlled area is 2 × 10^5 pCi/liter.

Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha-particle count—interpreted as uranium, the most likely source of radioactivity—of the 104 and the 130 air samples collected during the first half of 1969 at the perimeter fence and 1 mile, respectively, were 1.5 percent and less than 1 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The average beta-particle count of these samples was 0.11 percent of the standard at the perimeter fence and 0.03 percent of the standard at 1 mile.

Table 10. External gamma radiation levels, January–June 1969

Sample location[a]	Number of readings	Gamma radiation (mR/h)
At plant perimeter fence		
North	5	0.02
East	5	[b].04
South	5	.02
West	5	.02
Total	20	0.02
About 1 mile outside plant perimeter fence		
North	5	0.02
East	5	.02
South	5	.02
West	5	.02
Southeast	5	.02
Total	25	0.02

[a] See figure 5.

[b] Near uranium hexafluoride cylinder storage area.

The average uranium analyses of weekly water samples collected continuously from the Big Bayou Creek during January–June 1969 was 0.03 percent of the AEC standard for water beyond a controlled area. The results of the uranium analyses for each of the 5 grab samples collected at monthly intervals from the Ohio River below the plant were less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big Bayou Creek averaged 4.5 percent of the AEC standard for the decay products of uranium-238. The beta radioactivity of the Ohio River was less than 0.5 percent of the standard for uranium-238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for January–June 1969, except for the east plant perimeter station which had an average of 0.04 mR/h.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January–December 1968	October 1969

4. Portsmouth Area Gaseous Diffusion Plant[5] January–June 1969

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha-particle, beta-particle, and gamma-ray emitters.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 6. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1969, the waterborne alpha and beta-gamma radioactivity decreased over the calendar year 1968. The airborne alpha and beta-gamma remained essentially unchanged.

Penetrating background dose rates for the first half of 1969 were considerably lower when compared with the calendar year 1968 values. In the calculations, it is assumed that all of the dose rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

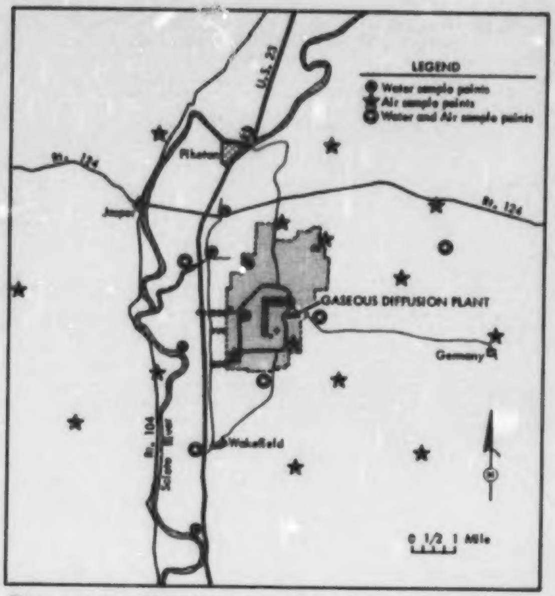

Figure 6. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 11. The external beta-gamma radiation

Table 11. Environmental radioactivity, Portsmouth Plant January–June 1969

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent standard[a]
Air:					
Alpha radioactivity, (pCi/m³)	126	0.9	0.1	0.1	5.0
Beta-gamma radioactivity, (pCi/m³)	126	2.2	.1	.2	.02
Water:					
Alpha radioactivity, (pCi/liter)	74	486	.5	39.8	.02
Beta-gamma radioactivity, (pCi/liter)	73	1,620	14	75.7	.38
Background exposure[b] (mrem/h)	122	.015	.000	.012	13.5

[a] The applicable radiation protection standards are as follows:

Air (alpha radioactivity)	2 pCi/m³
Air (beta-gamma radioactivity)	1 nCi/m³
Water (alpha radioactivity)	20 nCi/liter
External (beta-gamma radioactivity)	0.5 rem/a (approx. 0.6 mrad/h)

[b] Measurements were made with an open-shield Geiger-Mueller 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

---

[5] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, First Half 1969" (August 27, 1969).

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levels, measured at the air sampling locations shown in figure 6, are also summarized in table 11. The overall average concentrations and background exposure rates for 1968 and January–June 1969 are presented in table 12 as percent of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	January 1969
July–December 1968	November 1969

Table 12. Comparison of average concentrations Portsmouth, 1968–1969

Type of monitoring	Percent of AEC standard[a]			
	January–June 1968	July–December 1968	Calendar year 1968	January–June 1969
Air:				
Alpha radioactivity	<3.0	3.2	<5.0	<3.0
Beta-gamma radioactivity	.02	.03	.02	.02
Water:				
Alpha radioactivity	.13	.38	.26	.02
Beta-gamma radioactivity	.27	.55	.43	.38
Background exposure extrapolated to 3 feet above ground level	16.2	19.9	18.3	13.5

[a] See footnote (a) of table 11.

Reported Nuclear Detonations, March 1970

(Includes seismic signals from foreign test areas)

During March 1970, five United States nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Two low yield tests (less than 20 kilotons TNT equivalent) were conducted underground on March 6 and one test on March 19, 1970. A nuclear test in the low-intermediate yield range (20 to 200 kilotons of TNT equivalent) was conducted March 23, 1970.

An underground nuclear test with an estimated yield of more than a megaton was conducted March 26, 1970, in the Pahute Mesa area of the Atomic Energy Commission's Nevada Test Site at 11 a.m., P.s.t. The test, assigned the name of Handley, was approximately the same size as the Boxcar and Benham tests in 1968, the largest tests previously conducted at the test site.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip then for their files.

AN INVESTIGATION OF X RADIATION FROM COLOR TELEVISION RECEIVERS IN SUFFOLK COUNTY, NEW YORK. *Seymour Becker. Radiological Health Data and Reports, Vol. 11, April 1970,* pp. 179–182.

The results of an investigation of color television receivers at the homes of 6,482 residents in Suffolk County, who requested a radiation inspection after publication of the proposed study in the newspapers, is presented.

The survey consisted of two parts:

1. an investigation of only General Electric color television sets from July 1967 through August 1967; and
2. a radiation inspection of General Electric and 39 other types of television receiver requested by owners from January 1968 to December 1969.

X-radiation emissions were detected in 37 of the 40 name brands of color television sets checked. Over 1,000 (16.2 percent) color television sets emitted x radiation above the NCRP recommended guides. The x-ray emissions ranged above 0.5 mR/h to 150 mR/h at 5 cm from the television set.

X-radiation emissions were reduced to the natural background of the home by adequate modification and adjustment of the television components.

KEYWORDS: Color television receivers, county, New York State, survey, x radiation

STRONTIUM-90 IN HUMAN BONES IN THE UNITED STATES, 1962–1966. *E. J. Baratta, E. S. Ferri,* and *M. A. Wall. Radiological Health Data and Reports, Vol. 11 April 1970,* pp. 183–186.

The Bureau of Radiological Health has been conducting a continuous investigation of strontium-90 in human bones since late 1961. Autopsy specimens, mostly vertebrae, are collected by pathologists, medical examiners, and coroners in selected areas throughout the United States. The population of interest consists of children and young adults up to 25 years of age. Samples were collected from areas around six principal cities: Atlanta, Boston, Cincinnati, Los Angeles, New Orleans, and Seattle.

From 1962 through 1966, over 1,600 specimens have been analyzed. The specimens are grouped and analyzed according to age and area of residence. A review of the data shows that peak strontium-90 levels occurred in most age groups during the years 1963 and 1964. Decreasing values are shown in analyses for 1966 approaching those of 1962. A histogram of the frequency distribution for 1966 displays a slightly positive skewness which, when plotted, indicates a log normal distribution consistent with earlier observations on biological specimens.

KEYWORDS: Bone, human, strontium-90, United States

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 5, May 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
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Department of Health, Education, and Welfare
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health

Cesium-137 Concentrations in Eskimos, Spring 1968

J. A. Eckert[1], *J. S. Coogan*[1], *R. L. Mikkelsen*[2], and *P. N. Lem*[1]

To determine cesium-137 concentrations, 996 residents of 11 Alaskan villages were whole-body counted during April 1968. The methods of counting and selection of villages were chosen to complement the spring 1967 counts made by Rechen et al. The villages counted in this study were Ambler, Anaktuvuk Pass Village, Egegik, Kiana, Mekoryuk, Noatak, Noorvik, Selawik, Shishmaref, Shungnak, and Teller.

The maximum and average concentrations, considering all villages, were 24.27 nCi/kg and 4.37 nCi/kg, respectively. The average radiation dose index was 34.1 mrad/a. A comparison of the radiation dose indices of individuals counted both in the spring of 1967 and the spring of 1968 indicates that in two villages out of ten there was a significant decrease in the indices.

The inhabitants of villages living on a diet of caribou or moose meat had a higher cesium-137 burden than the inhabitants of villages where reindeer herds supply the main meat source.

The calibration formulas of Rechen and Palmer are compared and it is concluded that earlier studies made by Hanson and Palmer are compatible with the more recent studies made by the U.S. Public Health Service.

The Bureau of Radiological Health (BRH) instituted a surveillance program on the Alaskan native population in 1965 and is continuing this program at the present time (*1-3*). Bureau of Radiological Health participation followed earlier studies by Hanson and Palmer whose published results demonstrated a simple portable counting technique, the magnitude of the burdens in the areas counted, and some seasonal dependence (*4-6*). The results of the BRH whole-body counting for cesium-137 in the spring of 1967 determined the geographical distribution of the cesium-137 burdens, determined the burdens to a very large population (1,344 persons), and indicated that there was little dependency between cesium-137 burdens in village children and their participation in the Bureau of Indian Affairs school lunch program.

The overall objective of the spring 1968 survey was to continue surveillance of the cesium-137 levels. Of particular interest was the measurement of individuals who had been counted during the previous year for a direct comparison of the change in levels. Three villages, Barrow, Point Hope, and Wainwright, were dropped from the counting schedule because of the low levels found during the 1967 surveillance program. One village, Kiana, was added because the geographical location suggested high levels might be detected. The counting equipment and methods used were to be as nearly the same as possible to those used in the 1967 surveillance program to insure the validity of a direct comparison of results.

A rather extensive background on the reasons for this surveillance program can be found in Rechen et al (*1*). The counting procedure and equipment are essentially as described in the Rechen report. Individuals to be counted are seated and bent over the unshielded NaI crystal which is placed on their thighs. However, several exceptions were made in the equipment or methods in the interest of greater performance reliability in the field. Integrated 7.5- by 7.5-cm NaI crystal-photomultiplier assemblies were used and printed paper-tape output was selected. This output required more effort for data analysis but provided much greater reliability in the field than punched paper tape.

---

[1] Southwestern Radiological Health Laboratory, Bureau of Radiological Health, Las Vegas, Nev.

[2] Formerly, a Bureau of Radiological Health State assignee to the Alaska State Health Department, now with the Anchorage Borough Health Department, Anchorage, Alaska.

Four detectors were used simultaneously on four subjects to enable rapid counting of residents. Almost without exception, 4-minute counting times were used. This combination of multiple detectors and counting times enabled the investigators to count an entire village usually in 1 day.

All counts were analyzed using computer techniques. The data were analyzed by selecting the half full width at maximum (FWHM) of the cesium-137 photopeak after subtraction of a relevant background and summing all counts under the photopeak over the resultant energy range. This particular area under the photopeak was chosen to minimize errors due to gain shifts or differences in resolution between crystals. The calibration formula was identical to that used by Rechen (*1*) in 1967, except that a factor of 0.75 was introduced to compensate for the summation of the smaller area. The Rechen formula is nCi/CPM = 0.012 $(W)^{0.7}$. The calibration formula used in this study was:

$$\frac{\text{nCi}}{\text{CPM}} = 0.016\ (W)^{0.7}$$

where, nCi = total cesium-137 activity; (see Rechen et al.) (*1*);

W = body weight in kilograms;

CPM = counts per minute under photopeak limited by FWHM.

After calculating the burden using the above formula, a constant was added to the result to adjust for the burden of the background subject.

Background measurements in the villages were obtained by counting two of the investigators whose burdens had been determined by a large crystal whole body counter before and after the survey to insure the validity of the background burden. Dietary precautions were also taken by these individuals so as to minimize the uptake of cesium-137 during the period of the survey.

The results are also expressed in terms of the Radiation Dose Index (r_l). This parameter represents an estimate of the accumulative dose to the individual for 1 year if the body burden of cesium-137 were to be maintained at the same level for the year. A detailed discussion of this parameter can be found in the report of Rechen (*1*), and will not be duplicated here beyond a simple statement of the formula:

$$r_l = \left(W^{0.3} + 4.5\ \frac{\text{nCi}}{W} \right)$$

where, r_l = estimated total body dose in mrad/a;

W = body weight in kg; and

nCi = total cesium-137 concentration in nCi.

A Radiation Dose Index was computed for each individual rather than for population groups as per the Rechen report (*1*). Thus, data on population groups were obtained by averaging the individual indices.

Although Rechen (*1*) and Palmer (*4*) used the same counting method and calibration techniques, their respective calibration formulae were quite different. In figure 1 both formulae have been plotted, equating the two curves at a body weight of 70 kg. Note that both formulae yield the same results over an extended range of body weights. An attempt was made to verify the calibration formulae using residents of Nevada with inherently low body burdens of cesium-137. The body burdens were determined using large crystal (11- by 4 inch) whole-body counting techniques. The large crystal whole-body counting facility used was that operated by the Southwestern Radiological Health Laboratory in Las Vegas, Nev. Calibra-

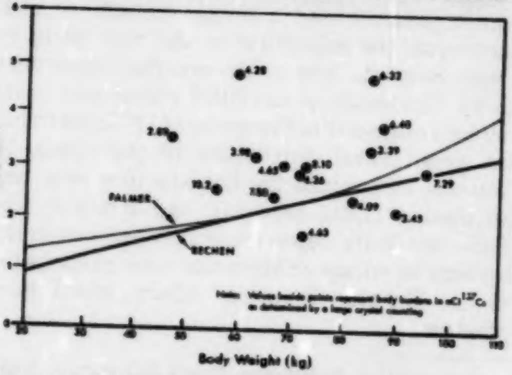

Figure 1. Comparison of calibration formula and whole body results
(Values beside points represent cesium-137 body burdens in nCi of Nevada residents as determined with a large crystal)

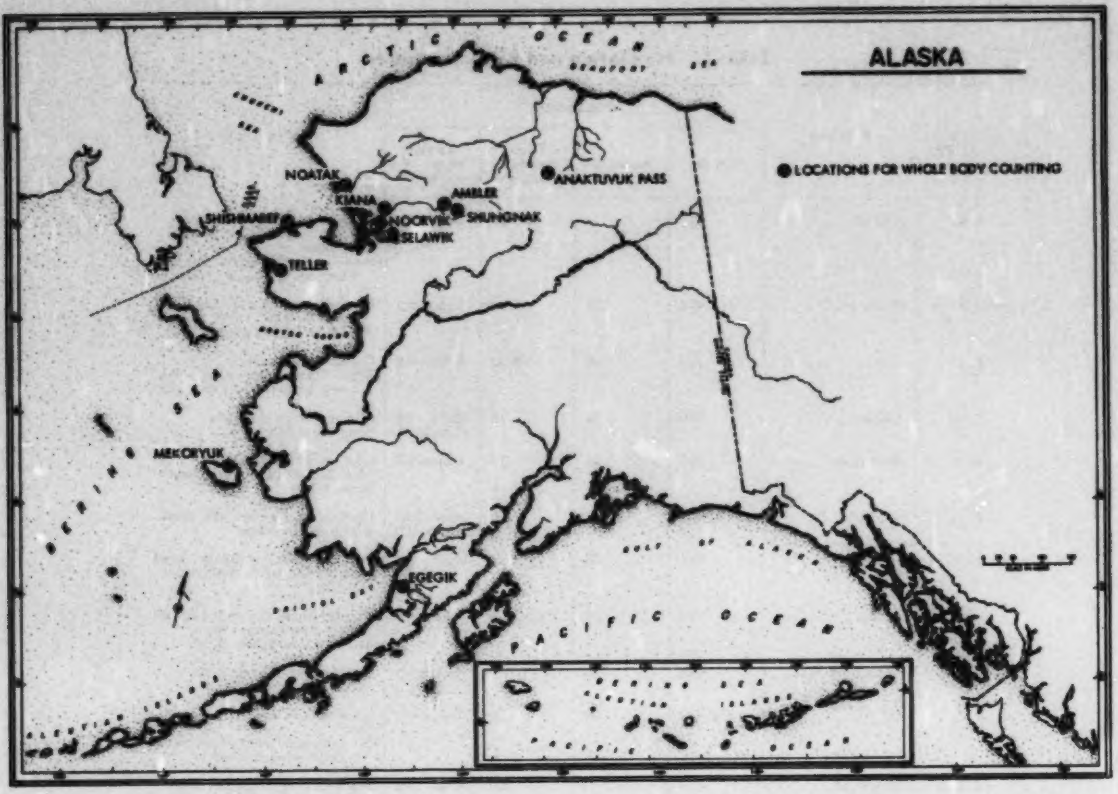

Figure 2. Alaskan locations for whole body counting, April 1968

tion was performed using a phantom constructed of cesium-137 spiked sugar bags. Immediately after being counted with the large crystal, the Nevada residents were counted using the "lap" technique, but in a large shielded enclosure rather than an unshielded room as experienced under field conditions. The values of the cesium-137 burdens in nCi, as determined using the large crystal, are plotted with the Rechen-Palmer curves in figure 2.

Dietary studies of Alaskan villages show that a large percentage of protein intake is obtained from local supplies. Data are available in current literature on three of the villages counted, Noatak, Shishmaref, and Shungnak, where the percentage of consumed protein from locally obtained food is 75 percent, 78 percent, and 81 percent, respectively (*7*). Individual dietary information was not collected, but rather, an overall view of food consumption in a village was obtained through interviews with village leaders. This information, as well as population information, is listed in table 1. The locations are noted in figure 2. In the population figures, the designation "High School Students" in all cases refers to students temporarily living at Bureau of Indian Affairs schools located away from the village.

Counting results and conclusions

Table 2 lists the average and maximum concentrations of cesium-137 in individuals and the average and maximum Radiation Dose Indices. The tabulation is by village, sex, and weight classification. Also listed are the counting dates, number of individuals counted, average height and average weight. Table 2 also includes summary information on all villages. The maximum recorded burden was 24.27 nCi/kg in a 52-year-old male living in Selawik. This individual weighed 69 kg giving a total burden of 1.7μCi. The Radiation Dose Index for this individual (also the highest value) was 195.7 mrad/a. The applicable

Table 1. Population and diet parameters

Date (1968)	Location	Population				Native diet
		Total[b]	Students[a]	High school students[a,b]	Adults above 16 years[a]	
4/6	Noatak	210	82	20-25	Unknown	Caribou plentiful all winter Seven moose killed in village Four bear Some Dolly Varden Trout and Shee fish taken all winter.
4/8	Noorvik	450	138	50	Unknown	Caribou far away from village; not plentiful Shee fish in good supply
4/9	Kiana	250	90	20-22	Unknown	Caribou, plentiful Moose, plentiful; Shee fish, catch beginning at this date
4/10	Ambler	140	44	10	Male 24 Female 31	Caribou in good supply Some Shee fish
4/11	Shungnak	176	54	19	Unknown	Caribou kill, light Most families killed a moose Some fishing
4/14	Selawick	430	130	50	Male 112 Female 100	Caribou and moose kill, good White fish—pickerel
4/16	Shishmaref	261	70	23	Male 62 Female 54	Walrus, seal, reindeer herd controlled by native herder Some fish
4/17	Teller	180	52	Unknown	Unknown	Reindeer herd controlled by native herder, some fish Mostly store-bought food
4/20	Anaktuvuk Pass	125	51	6	Unknown	Caribou supply, excellent (main stable of diet)
4/21	Egegik	180-200	59	10	Unknown	Caribou kill, excellent Fish Store-bought food constitutes a large portion of diet
4/22	Mekoryuk, Nunivak Island	325	95	20	Unknown	Main dietary components: BIA reindeer herd on island, duck, seal, a few walrus.

[a] Students, high school students and adults above 16 years are included in the total population.
[b] Students temporarily living at Bureau of Indian Affairs Schools located away from the village.

FRC Radiation Protection Guide is 500 mrad/a. A comparison of males and females of the same weight range and residing in the same village revealed that differences by sex in cesium-137 burdens is only important in the higher weight ranges, thus verifying the conclusion reached by Rechen. Males in the higher weight range have significantly higher burdens than females.

Table 3 presents a comparison of the results of the spring 1967 and spring 1968 whole-body counts. Data on the spring 1967 counts were taken from the Rechen report (*1*) and the data for 1966 were from Fitzpatrick (*3*). It should be noted that the Radiation Dose Indices for 1968 were based on averages of the individual radiation dose indices whereas the 1967 indices were based on group averages. The villages were counted in the spring of both years, thus, hopefully eliminating any seasonal dependence. In 43 of the 60 categories compared, the 1967 concentrations were higher.

Figure 3 shows a bar graph of the Radiation Dose Index for a particular category of males, 45–65 kg. A comparison of this graph and the dietary information listed in table 1 demonstrates that in general (Noatak being the exception) individuals in those villages relying on caribou and moose have higher cesium-137 burdens than those with reindeer herds. The villages with the highest concentrations (Ambler, Kiana, Noorvik, Selawik, and Shungnak) are located in the Kobuk River region. Investigations in the past have concentrated on caribou or reindeer as the principle link in the ecological chain responsible for the high cesium-137 burdens found in Arctic peoples. In Shungnak, where the burden was high (table 1) the residents were consuming primarily moose rather than caribou or reindeer. This would suggest the need to study the consumption of other native animals as possible sources of cesium-137.

Comparison of the calibration formulas of Rechen (*1*) and Palmer (*4*) showed very good

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Table 2. Spring 1968 maximum cesium-137 concentrations and Radiation Dose Indices for Alaskan Eskimos by place of residence, sex, weight and height

Location and counting dates (1968)	Sex	Weight range (kg)	Number counted	Average height (cm)	Average weight (kg)	Cesium-137 concentrations		Radiological Dose Indices (mrad/a)	
						Maximum (nCi/kg)	Average (nCi/kg)	Maximum	Average
Ambler 4/10	Male	< 45	13	137	31	15.20	8.73	108.9	63.6
		46–65	6	167	54	21.86	11.69	174.8	91.4
		> 65	6	172	83	14.69	6.89	118.1	58.8
	Female	< 45	13	137	34	11.56	6.08	80.3	49.4
		46–65	18	158	56	14.94	7.47	118.9	38.8
		> 65	7	161	76	6.88	4.41	55.5	36.1
Anaktuvuk Pass Village 4/30	Male	< 45	13	128	31	4.84	3.23	36.4	23.6
		46–65	3	157	54	7.46	4.61	56.7	36.3
		> 65	10	169	71	9.27	6.67	74.4	54.0
	Female	< 45	11	130	31	5.11	3.18	38.5	22.3
		46–65	13	155	55	9.26	5.12	72.1	40.0
		> 65	2	156	70	4.98	4.42	39.6	35.7
Egegik 4/21–4/22	Male	< 45	25	132	31	8.20	2.86	62.6	21.2
		46–65	13	169	57	5.84	3.35	44.3	25.6
		> 65	21	173	80	11.30	2.96	90.6	24.1
	Female	< 45	21	130	30	6.74	3.02	47.6	21.9
		46–65	15	158	56	4.75	2.68	37.4	21.1
		> 65	6	157	73	3.97	2.61	33.2	21.3
Kiana 4/9	Male	< 45	16	145	37	4.78	2.28	35.9	17.0
		46–65	12	160	56	7.33	3.50	58.3	27.6
		> 65	21	172	76	8.56	4.56	70.9	37.2
	Female	< 45	19	148	38	4.75	2.11	35.5	15.7
		46–65	25	156	56	5.40	2.94	43.5	23.1
		> 65	14	160	75	5.30	2.79	42.8	23.7
Mekoryuk, Nunivak Island 4/22	Male	< 45	31	136	34	6.93	3.62	51.1	26.7
		46–65	12	161	58	7.10	3.72	56.8	27.9
		> 65	9	168	73	3.65	2.43	29.5	19.9
	Female	< 45	16	140	38	6.45	3.32	48.5	24.8
		46–65	28	158	55	5.09	3.05	45.1	23.9
		> 65	10	157	77	5.16	2.73	42.0	23.3
Noatak 4/6	Male	< 45	7	147	40	3.82	2.05	29.0	15.5
		46–65	6	159	52	4.05	2.15	32.3	16.9
		> 65	33	172	77	6.63	3.43	54.0	28.0
	Female	< 45	7	137	36	3.44	1.73	26.0	13.0
		46–65	20	157	56	3.22	2.08	25.1	16.4
		> 65	11	158	74	2.46	1.48	19.9	12.0
Noorvik 4/8	Male	< 45	18	146	38	7.65	3.09	57.2	23.2
		46–65	24	167	57	8.23	4.79	66.3	37.9
		> 65	26	170	75	12.40	5.76	101.1	47.0
	Female	< 45	11	143	39	5.06	3.51	38.2	26.3
		46–65	35	158	57	8.30	3.91	65.6	30.8
		> 65	8	160	74	3.95	3.14	32.4	25.6
Selawik 4/14	Male	< 45	28	131	32	15.14	7.07	112.5	51.6
		46–65	20	161	57	13.86	7.54	110.9	59.4
		> 65	24	167	74	24.27	10.53	195.7	65.6
	Female	< 45	16	136	34	12.26	6.91	80.5	50.9
		46–65	21	153	57	14.85	7.05	117.3	55.4
		> 65	7	159	81	6.31	5.57	51.5	45.9
Shishmaref 4/16	Male	< 45	14	138	34	7.66	3.89	55.5	28.7
		46–65	10	161	58	6.80	4.34	54.2	34.3
		> 65	34	169	77	8.07	4.49	65.8	36.6
	Female	< 45	16	141	36	4.40	2.88	30.8	21.4
		46–65	16	156	57	7.07	3.02	55.2	23.8
		> 65	12	156	78	3.90	2.51	31.7	23.2
Shungnak 4/13	Male	< 45	16	141	35	11.37	5.98	84.2	44.4
		46–65	6	164	58	11.42	6.66	90.8	66.5
		> 65	12	176	78	17.53	8.25	142.1	67.4
	Female	< 45	9	139	34	8.31	4.80	62.9	35.4
		46–65	17	156	55	17.00	7.52	135.8	56.9
		> 65	5	159	70	8.80	5.30	70.5	42.8
Teller 4/17	Male	< 45	17	143	38	5.94	3.59	45.3	26.8
		46–65	15	165	58	4.85	3.50	38.5	27.5
		> 65	12	170	75	8.69	3.58	71.1	29.1
	Female	< 45	15	140	36	4.11	2.11	29.7	15.7
		46–65	15	154	54	3.90	2.20	30.6	17.2
		> 65	4	168	70	3.29	2.71	26.5	22.0
Total 4/6–4/22/68	Male	< 45	198	138	35	15.20	4.32	112.5	31.8
		46–65	127	162	56	21.86	5.01	174.8	39.6
		> 65	208	170	76	24.27	5.27	195.7	43.0
	Female	< 45	154	138	35	12.26	3.63	80.5	27.0
		46–65	223	156	56	17.00	4.19	135.8	33.0
		> 65	86	159	75	8.80	3.12	70.5	25.5

Table 3. Comparison of 1966, 1967, and 1968 average and maximum concentrations of cesium-137 in Alaskan Eskimos by place of residence, sex, and weight

Location	Sex	Weight range (kg)	Number counted			Average weight (kg)			Ratio of maximum concentrations		Ratio of average concentrations	
			1966	1967	1968	1966	1967	1968	1967/1966	1968/1967	1967/1966	1968/1967
Ambler	Male	<45		19	13		29	31		1.09		1.04
		45–65		9	5		58	54		1.29		1.17
		>65		13	6		77	65		.79		.62
	Female	<45		17	13		30	34		.82		.85
		45–65		20	18		57	58		.85		.82
		>65		8	7		73	76		.94		.90
Anaktuvuk Pass Village	Male	<45		4	13		34	31		.67		.82
		45–65	3	6	3	29	60	54	1.10	.40	.92	.52
		>65	5	14	10	74	72	71	1.30	.55	.82	.79
	Female	<45		4	11		37	31		.55		.56
		45–65		13	13		55	55		.91		.88
		>65		3	3		73	70		.88		.90
Kiana	Male	<45		25	20		31	31		1.15		1.29
		45–65	12	18	13	56	57	57	1.04	.29	.81	.77
		>65	19	14	21	77	79	80	.90	1.57	1.09	1.05
	Female	<45		15	21		28	30		.98		.86
		45–65		14	15		54	58		.88		1.18
		>65		4	6		74	75		.80		.61
Mekoryuk, Nunivak Island	Male	<45		13	31		32	34		1.72		1.47
		45–65		16	12		58	56		1.11		.75
		>65		16	9		73	73		.47		.52
	Female	<45		11	16		34	28		1.07		1.34
		45–65		22	26		57	55		1.18		[illegible]
		>65		8	10		75	77		1.06		1.37
Noatak	Male	<45		24	7		31	40		.64		.78
		45–65		13	6		59	62		.30		.52
		>65		34	32		75	77		.71		.57
	Female	<45		24	7		32	36		.58		.74
		45–65		32	20		58	56		.54		.58
		>65		15	11		77	74		.55		.56
Noorvik	Male	<45		23	18		35	38		.58		.56
		45–65	1	25	24	64	55	57	2.82	.45	1.33	.56
		>65		35	26		73	75		.62		.52
	Female	<45		10	11		35	30		.51		.56
		45–65		37	35		57	57		.57		.56
		>65		15	8		75	74		.37		.72
Selawik	Male	<45		32	28		30	32		.91		.87
		45–65	11	19	30	61	59	57	.79	.71	.65	.66
		>65	23	15	26	73	76	74	.54	1.40	.56	1.08
	Female	<45		45	16		28	34		.76		.88
		45–65		40	21		55	57		.81		.79
		>65		14	7		78	81		.48		.74
Shishmaref	Male	<45		22	14		30	34		1.09		1.11
		45–65		15	10		59	68		.62		.89
		>65	1	25	34	77	77	77	1.32	.70	.74	.96
	Female	<45		22	18		30	35		.64		.81
		45–65		28	16		54	57		1.15		.93
		>65		10	12		77	78		.88		.79
Shungnak	Male	<45		20	16		29	33		1.04		.95
		45–65		14	6		56	58		.86		1.01
		>65		13	12		74	75		.97		.68
	Female	<45		22	9		28	34		.77		.75
		45–65		23	17		55	55		1.41		1.14
		>65		3	5		72	70		1.49		1.23
Teller	Male	<45		14	17		32	38		1.51		1.72
		45–65		15	15		60	58		.77		.91
		>65		9	12		75	75		1.24		.91
	Female	<45		19	15		33	36		.94		1.10
		45–65		18	15		56	54		.63		.96
		>65		6	4		74	70		.97		1.71
Total	Male	<45		232	196		32	35		.92		1.09
		45–65	34	188	127	60	58	58	.70	1.13	.71	.96
		>65	88	250	206	73	76	76	.54	1.16	.78	.93
	Female	<45		231	154		32	35		.76		.92
		45–65		285	223		55	56		.96		.96
		>65		120	86		74	75		1.02		1.18

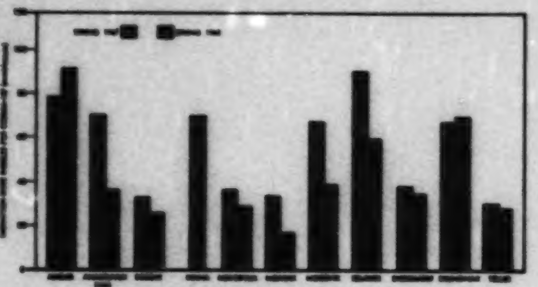

Figure 3. Radiation dose indices for cesium-137, males 45-65 kg

agreement, particularly in the weight range from 50 to 80 kg (figure 1). Thus, the results of Hanson and Palmer (*5–6*) can be directly compared to the studies made by the Bureau of Radiological Health. Cesium-137 burdens were low with a resulting large dispersion of the experimental data in the laboratory calibration.

For each village, a statistical test was performed on the data to determine if there were significant differences between the 1967 and 1968 values. The tests were made only on those individuals in the ten villages who had been counted both years (table 4). The structure of the test was the standard t-test for comparing two means. At the 95-percent confidence level ($\alpha = 0.05$), the populations in four villages (Noatak, Noorvik, Selawik, and Teller) had significant differences between the 1967 and 1968 body burdens. At the 99-percent confidence level, the populations in two villages (Noatak and Noorvik) had significant differences. The authors conclude that the lower levels found in 1968 in Noorvik and Noatak are significant reductions but a statement of a general reduction in all villages and individuals would be unwarranted. It would appear that it is not possible to predict any long-term trend from the present data.

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Table 4. Comparison of village populations counted 1967–1968[a]

Village	1967			1968			Differences in means $\bar{x}$(1968)–$\bar{x}$(1967)	Level of significance $\alpha = .05$	Level of significance $\alpha = .01$
	Number counted (*n*)	Concentration (nCi/kg) Mean ($\bar{x}$)	Concentration (nCi/kg) Deviation (*s*)	Number counted (*n*)	Concentration (nCi/kg) Mean ($\bar{x}$)	Concentration (nCi/kg) Deviation (*s*)			
Ambler	53	8.04	3.28	53	7.65	3.83	0.39	No	No
Anaktuvuk	26	6.11	2.78	26	5.58	1.97	.53	No	No
Egegik	55	2.93	2.43	55	2.97	1.46	.04	No	No
Mekoryuk	45	3.11	1.20	45	3.01	1.14	.10	No	No
Noatak	60	4.04	2.16	60	2.48	1.36	1.56	Yes (decrease)	Yes
Noorvik	72	7.58	3.57	72	4.24	2.08	3.34	Yes (decrease)	Yes
Selawik	71	8.63	3.43	71	7.32	2.91	1.31	Yes (decrease)	No
Shishmaref	69	4.06	1.84	69	3.73	1.57	.33	No	No
Shungnak	53	7.40	3.20	53	7.22	3.80	.18	No	No
Teller	32	2.61	1.47	32	3.33	1.70	.72	Yes (increase)	No

[a] Total number individuals counted in both 1967 and 1968 is 536.

Tritium Body Burden of Children, 1967-1968

A. A. Moghissi and *Robert Lieberman*[1]

The tritium concentration in body water of children was determined from samples of urine taken from two children in each of nine Institutional Total Diet Sampling stations. The tritium concentrations in body water of children gradually decreased from about 1.5 nCi/liter to less than 0.2 nCi/liter during the period, January 1967 to December 1968. Several anomalies were noted.

The dose equivalent from tritium for standard man was calculated to be 0.15 mrem for 1967 and 0.13 mrem for 1968. The dose equivalent for children varies according to age and is roughly 0.1 mrem for a 13-year-old child.

After the cessation of atmospheric nuclear testing, tritium concentration in the environment has continuously decreased. Tritium is, however, produced in nuclear reactors and is eventually introduced into the hydrosphere. The Bureau of Radiological Health (BRH) has recognized the importance of this radionuclide and has established a number of networks to evaluate a possible radiation hazard to the public. Analytical results of surface water networks (*1*) are continuously reported. Similarly, rain is continuously monitored for tritium (*2*).

The ultimate purpose of most networks is the evaluation of the radiation dose or, to be more explicit, the dose equivalent (DE) to man. The most suitable medium for the radiobioassay of tritium is body water. It is well known that tritiated water introduced into the body is evenly distributed in the body water within a short period of time. (*3*).

The body burden may thus be expressed as the concentration of tritium in the body water, and urine may be used for radiobioassay and the evaluation of DE. In connection with the Institutional Total Diet Sampling Network Program (ITDSNP) (*4*), urine samples from children in several children's homes were analyzed for a number of radionuclides at the Southeastern Radiological Health Laboratory. During the 1967–1968 period a portion of these samples was radioassayed for tritium.

Sampling and analysis procedures

Samples were collected from 9 ITDSNP stations distributed throughout the continental United States. The locations of these stations are shown in figure 1. To obtain a reasonable sampling accuracy, samples were collected from two children from each home. Samples were collected in disposable containers and an aqueous (1 ml) solution of merthiolate was used as a preservative. Upon arrival at the laboratory, the samples were logged and stored in a cold room at a temperature of 0–4° C.

Approximately 30 ml of the urine were distilled in all glass equipment using potassium persulfate as an oxidizing agent (*5*). Tritium assay was carried out by liquid scintillation counting, using a dioxane-based scintillation liquid (*5*). Twenty ml of dioxane, containing 7 g of 2,5 diphenyloxazole (PPO) and 1.5 g of p-bis-(methylstyryl)-benzene (bis-MSB) in 1 liter, was mixed with 5 ml of distilled urine and counted in a Beckman liquid scintillation counter. Duplicate samples were prepared and each was counted for 50 minutes twice. A background sample was counted prior to the first sample and a second background sample counted after the second replicates. If any one of the 50-minute sample counts deviated by more than 2σ from the average, the duplicates were recounted. The minimum limit of detection (MLD) of this system at 2σ confidence level was 0.2 nCi/liter. Beginning with the July 1968 samples, one of the replicates was counted using a suspension technique (*6*). A p-xylene solution containing 7 g

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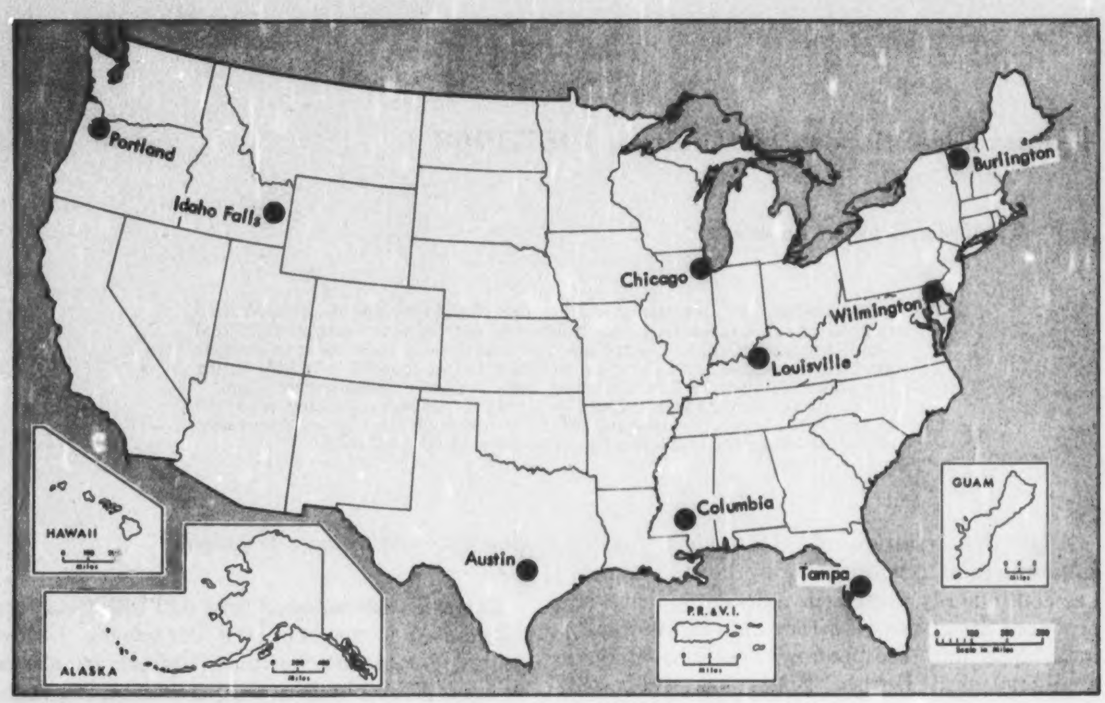

Figure 1. Nine Institutional Total Diet Sampling stations)

PPO and 1.5 g bis-MSB/liter was mixed with a detergent, Triton N101 (a product of Rohm and Haas, Philadelphia, Pa.), in a volume ratio of 2.75:1. Fifteen ml of xylene-detergent mixture and 10 ml of water were thoroughly mixed and counted. The details of this procedure are described by Lieberman and Moghissi (*6*). The minimum limit of detection of this suspension technique was 0.1 nCi/liter.

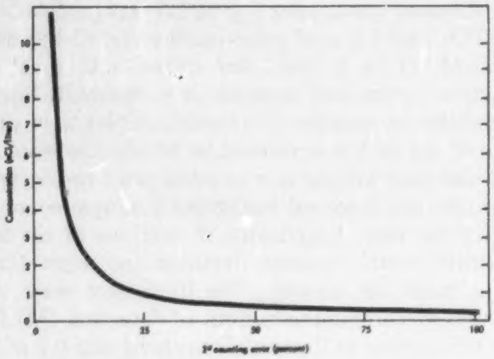

Figure 2. Correlation between the tritium concentration of water and the counting error in percent at 2-sigma confidence level

Although the samples counted during the latter part of 1968 had a lower minimum limit of detection, for the sake of uniformity and because the new procedure was in an experimental state, 0.2 nCi/liter is used as the MLD for the entire period. Figure 2 shows the counting error at 95-percent confidence level for the activity range of this investigation.

Results

From tables 1 and 2, it may be seen that tritium concentrations in the body water of children have gradually decreased in some cases, from approximately 1.5 nCi/liter to less than 0.2 nCi/liter from January 1967 to December 1968.

Certain anomalies are, however, striking. In several cases, the two samples collected from children in the same home show considerable discrepancy. Originally, this was attributed to analytical inaccuracies. In all these cases, however, a rerun of the samples confirmed the original findings.

In search for a reason, a number of possibilities were considered. The water or food intake was the first possibility. It is, however, highly improbable

Table 1. Tritium concentration in urine, 1967

Location	Concentration (nCi/liter)											
	January	February	March	April	May	June	July	August	September	October	November	December
Vt: Burlington	1.8 1.7	1.5 1.4	1.4 1.5	1.5 NS	1.0 .7	0.5 .9	NS NS	NS NS	NS NS	NS NS	NS NS	NS NS
Del: Wilmington	1.2 1.3	.6 1.3	.8 .8	.5 .4	NS .4	.5 .4	0.4 .6	1.3 1.4	0.4 NS	0.3 .3	NS NS	0.3 .2
Ky: Louisville	4.0 1.8	3.0 1.3	3.2 1.1	1.0 1.0	1.8 .5	.8 .4	1.2 .8	2.8 1.8	.9 .8	NS NS	.5 .6	NS NS
Fla: Tampa	1.0 1.0	NS NS	.5 .4	.5 .7	< .2 < .3	.2 < .3	.2 < .3	< .2 .2	.4 3.0	NS NS	NS NS	< .2 < .2
Miss: Columbia	1.6 1.2	.4 .5	.7 .6	.4 < .3	.3 .3	.2 < .2	< .2 < .3	.8 .8	.3 < .3	< .2 < .2	.3 .4	.2 < .3
Ill: Chicago	1.6 1.3	.6 NS	.6 .6	.7 .6	.7 .5	.3 .5	.4 .4	1.2 .8	NS NS	.4 .4	NS NS	.2 < .3
Ore: Portland	.8 NS	1.2 NS	1.2 1.0	.6 .5	.4 .3	.3 .3	NS NS	NS NS	.4 .3	.3 < .2	NS NS	NS NS
Tex: Austin	1.3 1.2	.9 .8	.9 .9	.9 .6	.3 .2	.3 < .3	.4 NS	.8 6.0	.6 4.9	.4 NS	.3 .4	< .3 .3
Idaho: Idaho Falls	1.4 1.3	NS NS	1.3 1.0	1.0 1.0	.4 .8	.5 .7	1.0 .8	12.0 .9	.4 NS	.2 .6	NS NS	.5 3.8

NS, no sample.

Table 2. Tritium concentration in urine, 1968

Location[a]	Concentration (nCi/liter)											
	January	February	March	April	May	June	July	August	September	October	November	December
Del: Wilmington	0.2 < .2	<0.2 < .2	0.5 1.0	0.5 < .2	0.2 .5	1.9 1.2	0.4 < .2	0.9 .8	0.2 .4	<0.2 < .2	0.2 .2	7.2 .4
Ky: Louisville	.6 .4	.5 .9	.2 NS	.5	.4	.8 .4	.5 NS	.5 NS	.5 NS	1.4 NS	.3 NS	.5
Fla: Tampa	4.5 9.6	< .2 < .2	NS NS	< .2 .4	< .2 .2	.2 .2	< .2 < .2	.2 < .2	.4 .8	< .2 < .2	< .2 NS	.4 NS
Miss: Columbia	.5 < .2	.4 2.2	2.0 < .2	.2 < .2	2.4 .4	.4 4.0	< .2 < .2	< .2 .4	1.0 .7	< .2 < .2	< .2 NS	< .2 < .2
Ill: Chicago	.2 5.7	.9 2.0	< .2 4.0	2.0 .9	.4 < .3	NS NS	NS NS	.4 .4	NS NS	NS NS	NS NS	NS NS
Ore: Portland	< .2 < .2	NS NS	.6 < .2	6.0 < .2	.2 .2	.6 .4	< .2 < .2	< .2 < .2	1.0 .8	< .2 .6	< .2 < .2	6.0 < .2
Tex: Austin	NS NS	< .2 < .2	< .2 < .2	< .2 < .2	< .2 < .2	.2 .4	.4 .4	< .2 < .2	< .2 < .2	1.0 < .2	< .2 < .2	.2 .8
Idaho: Idaho Falls	5.0 4.7	.9 2.0	1.4 .9	.8 .6	.5 .7	.5 .5	1.0 .8	NS NS	1.0 1.0	.5 < .2	.6 .8	1.0 1.0

[a] No samples were received from Burlington, Vt., during 1968
NS, no sample received.

that a person living in Tampa, Fla., would have a tritium body burden of 9.6 or 4.5 nCi/liter (January 1968) as water collected in that area had a tritium concentration of less than 0.2 nCi/liter. Tritium concentration in food collected during the same month was less than 0.2 nCi/liter (7) of water of combustion.

It is also unusual that two children from Wilmington, Del., having essentially the same tritium intake, show differences of almost 7 nCi/liter (December 1968).

A second possibility is the contamination of the sample during the sample collection and analysis. This possibility was systematically investigated. Forty-five disposable containers randomly selected from a variety of shipments were filled with 1 liter of water and left in the cold room for 14 days. These water samples were subsequently processed in the same manner as the urine samples and counted. No case of increased activity could be observed.

The only other possibility was the contamination of the samples during the shipment. One characteristic of the samples showing anomalies was their condition on arrival. They were generally spoiled, presumably due either to improper preservation or because the container was washed prior to sample collection, thus removing the preservative.

It is known that the specific activity of hydrogen (*8*) and methane (*9*) in the atmosphere is several orders of magnitude higher than that of atmospheric moisture. If during the biochemical reactions that occur during spoiling of urine samples, methane becomes incorporated into the aqueous portion of the urine, then an increased specific activity may result. The true reason for the relatively high specific activities found remains unknown for the time being. Further investigations are necessary to clarify this phenomenon.

Dose calculations

Moghissi and Porter (*1*) proposed the following equation for the calculation of tritium dose under equilibrium conditions:

$$DE = 10^{-1}C(QF)$$

where,

DE = dose equivalent in mrem/a;
C = concentration of tritium in the body in nCi/liter; and,
QF = quality factor for tritium.

This equation assumes a body weight of 70 kg of which 10 percent is hydrogen. To facilitate the dose calculation, it is assumed that the hydrogen concentration of the body is essentailly independent of age. This assumption is substantiated by the findings of Forbes (*10*) who has shown that the body water to body weight ratio changes only slightly with age. He also determined the body weight of children as shown in table 3. As the sex of the children was not recorded, the average weights were used in the calculations.

Since the publication of the above equation, Evans (*11*) has found that under continuous exposure, the specific activity of organically-bound and aqueous hydrogen is essentially the same. This finding confirms the underlying idea leading to that equation and is in conflict with the recommendations of ICRP (*12*).

Table 3. Body weight of children

Age (years)	Weight (kg)		
	Male	Female	Average
9	30.5	32	31.25
10	32	35	33.5
11	37	38	37.5
12	43.5	41	42.25
13	45	48	46.5
14	51	56	53.5

Numerous investigations have been published recently dealing with the quality factor (QF) of tritium. Feinendegen (*13*) has reviewed the literature extensively. Vennart (*14*) in a recent review has proposed a QF of 1. It is unfortunate that none of these papers reviews Shtukkenberg's (*15*) paper where a QF of 3 was proposed. Although Lambert (*16*) found recently that a QF of 1.3–2.4 was more appropriate, the International Commission on Radiological Protection decided to follow Vennart's recommendation (*17*) and has proposed a QF of 1 for tritium. Since no definite decision has been made by the National Commission on Radiation Protection and Measurements, a QF of 1.7 was found to be appropriate and is used in the calculations.

To evaluate the dose, all values of less than 0.2 nCi/liter are assumed to be 0.1 nCi/liter. This

Table 4. Average tritium concentrations in urine of children, total body burden, and dose equivalents for the standard man

Location	1967			1968		
	Concentration in urine (nCi/liter)	Total body burden (nCi)	Dose equivalent (mrem)	Concentration in urine (nCi/liter)	Total body burden (nCi)	Dose equivalent (mrem)
Vt: Burlington	1.26	79.4	0.21			
Del: Wilmington	.67	42.2	.11	0.[illegible]	45.4	0.12
Ky: Louisville	1.46	92.0	.25	.56	35.3	.10
Fla: Tampa	.48	30.2	.08	.89	56.1	.15
Miss: Columbia	.40	25.2	.07	.68	42.8	.12
Ill: Chicago	.62	39.1	.11	1.42	89.5	.24
Ore: Portland	.54	34.0	.09	.79	49.8	.13
Tex: Austin	1.02	64.3	.17	.22	13.9	.04
Idaho: Idaho Falls	1.50	94.5	.26	1.20	75.6	.20
Average	0.88	55.6	0.15	0.81	51.0	0.13

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value is estimated to be the current tritium level in surface waters of low specific tritium activity. Also high values are used in the averaging process although there is a probability that the calculated dose would be somewhat too high.

Table 4 shows the average tritium concentrations in the body water of children at the various sampling stations. The total body burdens are calculated for standard man, assuming that the tritium concentration in the body of standard man would be essentially the same as that in the bodies of children. The DE is calculated also for standard man and is included in the tables. The DE for standard man during 1967 was 0.15 mrem and during 1968, 0.13 mrem.

Table 5 shows the average total body burden and the DE for various ages calculated for the average tritium concentration.

Table 5. Tritium total body burden (TBB) and the dose equivalents (DE) of children during 1967 and 1968

Age (years)	Total body burden (nCi)		Dose equivalents (mrem)	
	1967	1968	1967	1968
9	24.8	22.8	0.067	0.061
10	26.6	24.4	.071	.066
11	29.8	27.3	.080	.074
12	33.5	30.8	.080	.085
13	36.9	33.8	.099	.091
14	42.5	38.9	.114	.106

The DE for children varies according to age and is roughly 0.1 mrem for a 13-year-old child.

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Tritium Concentrations in Food, 1967-1968

A. A. Moghissi and R. J. Lyon[1]

Tritium concentrations were determined in food samples obtained from several children's homes in the United States. The average concentrations of tritium in food indicate a decreasing trend from 1967 to 1968. The average dose equivalent from tritium in food was calculated to be 0.[illegible] mrem for 1967 and 0.06 mrem for 1968.

Due to the biological significance of tritium, the Bureau of Radiological Health has for several years evaluated the radiological health aspects of this radionuclide. The results of studies dealing with surface waters, (*1*), rain (*2*), and urine (*3*) have been reported.

According to the recommendations of the International Commission on Radiological Protection (ICRP) (*4*) more than half of the tritium intake is through food. Uncertainties regarding the biological half life of tritium incorporated in the organic molecules of food justified an evaluation of the tritium present in food.

Sampling and analysis procedures

Food samples collected from several children's homes distributed throughout the continental United States were shipped to the Southeastern Radiological Health Laboratory. These homes were instructed to collect the total food intake of the children, including soft drinks, during a period of 24 hours. The only medium not included was tap water.

In the laboratory, the sample was homogenized and approximately 100–150 grams were combusted. The collected water was distilled and counted for tritium.

Combustion procedure

The details of the combustion technique are shown in figure 1. Air is passed through a column (D_1) containing a desiccant and molecular sieve (Linde 13 A) to remove water and organic compounds originating from air compressors. The purified air was passed through a copper oxide catalyst which was kept at 500 to 600° C. in a furnace (F_1). This step was necessary to oxidize hydrogen and methane in the air which are known to contain tritium (*5, 6*) at levels several orders of magnitude higher than atmospheric moisture. The resulting water was collected in the drying column (D_2). The sample (S) which was placed in the furnace (F_2) was partially combusted as the air passed by. The completion of combustion occurred in the furnace (F_3) in the presence of a copper oxide catalyst at 500–600° C. At the beginning of the process F_2 was gradually heated from room temperature to 600° C. within 2 hours. An additional 2 hours were necessary to remove the possible residues of the sample, making it possible to run two samples in a working day.

Subsequent to the completion of this work, the catalyst was replaced by a platinum-aluminum oxide catalyst[2]. This catalyst could be used at a lower temperature of 150–200° C. and thus was considerably more effective.

Accuracy of the combustion

Significant errors may be introduced in the results of chemical reactions dealing with tritium if the reaction is incomplete. This phenomenon is caused by isotope effect and is the basis for enrichment of deuterium and tritium.

To evaluate the reproducibility of this combustion system, approximately 5 g of a rat tissue from a tritium experiment was mixed with the food and combusted. The entire procedure was

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[2] The catalyst was obtained from the Englehard Industries, Newark, N.J.

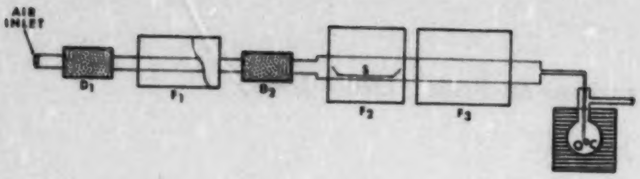

Figure 1. Schematic diagram of the combustion system

then repeated several times. The resulting water samples were distilled and counted as described below. Results of the replicates are shown in table 1. It can be seen that the standard deviation of the mean compares favorably with the counting error of the individual samples at the 2 σ confidence level.

Table 1. Accuracy of the food tritium analysis

Run number	Concentration in water of combustion (nCi/liter)
1	6.1 ± 0.3
2	5.9 ± .3
3	6.3 ± .3
4	6.0 ± .3
5	5.7 ± .3
Average	6.0 ± 0.2

Liquid scintillation counting

All samples were counted in a Beckman liquid scintillation counter. The details of the sample preparation are described by Moghissi et al (*7*). In short, 1 liter of scintillation liquid was prepared by dissolving 7 g of 2, 5-diphenyloxazole (PPO), 1.5 g of p-bis-(methystyryl)-benzene (bis-MSB) and 120 g of naphthalene in dioxane. Duplicate samples were prepared using 20 ml of this scintillation liquid and 5 ml of water. The total counting time for the duplicate was 200 minutes divided into four 50-minute counts. If any of the 50-minute counts deviated by more than 2 σ from the average, the duplicates were recounted. This occurred with a frequency comparable to the statistical expectancy. A background sample was counted prior to the first sample and a second background subsequent to its duplicate. The minimum limit of detection (MLD) of the counting was 0.2 nCi/liter at the 2 σ confidence level. Starting July 1968, one of the replicates was prepared using an emulsion mixture (*8*). A p-xylene solution containing 7 g PPO and 1.5 g bis-MSB per liter was mixed with Triton N 101 in a volume ratio of 2.75:1. Fifteen ml of this mixture were mixed with 10 ml of water resulting in a MLD of 0.1 nCi/liter. As this mixture was used in an experimental stage and for the sake of uniformity, all results are reported with an MLD of 0.2 nCi/liter and the counting error of the dioxane-based solution shown in figure 2.

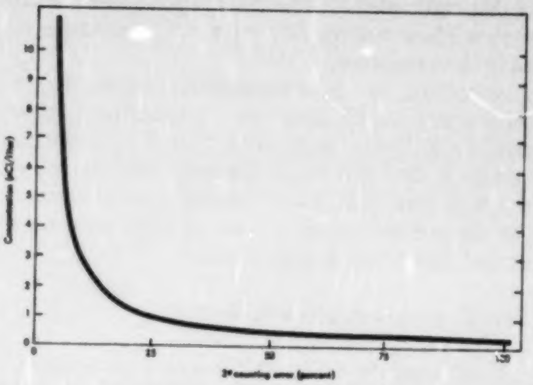

Figure 2. Correlation between the tritium concentration of water and the counting error in percent at 2-sigma confidence level

Results

The location of the stations and the analytical results are shown in tables 2 and 3. The decreasing trend as observed in surface water (*1*), rain (*2*) and urine (*3*) is evident in average values of 1968 as compared to 1967. A clear trend in individual samples is, however, not evident. The October 1968 value from Tampa, Fla., is considerably higher than other values during the entire period of 1967–1968. Similar values may be observed for other sample collection sites (Albuquerque, N. Mex., June 1967; Charleston, S.C., December 1967; etc.). This apparent lack of systematic decrease may be explained by the complexity of the food. Individual components of the samples could have originated from geographical areas

Table 2. Tritium concentration in food, 1967

Location		Concentration (nCi/liter of water of combustion)											
		January	February	March	April	May	June	July	August	September	October	November	December
Fla:	Tampa	0.5	0.5	0.9	0.4	NS	NS	0.5	<0.2	<0.2	0.8	<0.2	<0.2
La:	New Orleans	NS	.4	.5	.3	0.2	1.0	.6	1.0	<0.2	.9	NS	1.0
Ark:	Little Rock	< .2	.5	.4	.5	.2	.4	.2	< .2	NS	.3	.2	.4
Ky:	Louisville	NS	NS	1.0	1.1	> .2	.8	.6	.8	NS	.6	.4	1.0
N. Mex:	Albuquerque	.4	.6	.5	> .2	> .3	1.2	.5	NS	.3	NS	.6	NS
S.C:	Charleston	NS	.6	.6	.3	1.5	> .2	> .2	1.1	.2	.4	NS	2.0
Miss:	Columbia	.3	.2	.8	.4	.4	> .2	1.0	.3	NS	.4	NS	< .2
Tex:	Austin	.3	.6	1.0	> .2	> .2	1.0	NS	< .3	.5	< .3	< .2	< .2

NS, no sample received.

Table 3. Tritium concentration in food, 1968

Location		Concentration (nCi/liter of water of combustion)											
		January	February	March	April	May	June	July	August	September	October	November	December
Fla:	Tampa	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.3	<0.2	<0.4
La:	New Orleans	< .2	< .3	< .2	< .2	< .2	< .2	NS	< .2	< .2	< .2	.5	< .2
Ark:	Little Rock	< .2	.3	< .2	.2	< .2	< .2	< .3	< .2	< .2	< .2	< .2	< .2
Ky:	Louisville	.4	.3	.3	.3	.2	.2	< .2	.3	.3	.3	NS	.2
N. Mex:	Albuquerque	.4	.3	.4	.2	< .3	< .2	NS	.3	< .2	< .2	NS	.4
S.C:	Charleston	.3	.3	.3	.3	.3	< .2	< .2	< .3	NS	.3	.3	.5
Miss:	Columbia	< .2	< .3	< .2	< .2	< .2	< .2	NS	< .2	< .2	.5	NS	.5
Tex:	Austin	< .3	< .3	< .2	.2	< .2	< .2	NS	.2	.3	.5	NS	.6

NS, no sample received.

with different tritium concentrations than the collection site. Similarly, the preservation of food makes it possible that part of the food could have originated at a time when the tritium concentration was higher than that at the collection time. In the averaging process these effects are minimized so that a decrease is evident.

Dose calculation

In order that the dose equivalent to the population could be calculated, the average annual tritium concentration was used. For the purpose of averaging 0.1 nCi/liter was assumed to be the tritium concentration of values below the MLD. The following equation (*1*) was used for dose calculation:

$$DE = 10^{-1}(QF)C \qquad \ldots(1)$$

where

DE = dose equivalent in mrem/a;
QF = quality factor for tritium; and,
C = concentration of tritium in the body in nCi/liter.

Although ICRP has recommended a reduction of QF for tritium from 1.7 to 1, for the sake of uniformity with the dose calculations made for the same period using other media and for reasons described elsewhere (*3*), a QF of 1.7 is used in the dose estimations.

For the purpose of calculation it is assumed that the tritium concentration of the body is in equilibrium with that in food. It can be seen in table 4 that the average DE as calculated for food is somewhat lower than the averages calculated from body burden measurements for standard man of 0.15 mrem for 1967 and 0.13 mrem for 1968. This may be explained by the uncertainties

Table 4. Average tritium concentrations in food and the dose equivalents

Location	1967		1968	
	Concentration (nCi/liter)	Dose equivalent (mrem)	Concentration (nCi/liter)	Dose equivalent (mrem)
Fla: Tampa	0.38	0.06	0.14	0.02
La: New Orleans	.60	.10	.14	.02
Ark: Little Rock	.34	.06	.13	.02
Ky: Louisville	.71	.12	.26	.04
N. Mex: Albuquerque	.48	.08	.24	.04
S. C: Charleston	.69	.12	.26	.04
Miss: Columbia	.40	.07	.18	.03
Tex: Austin	.36	.06	.23	.04
Annual average	0.[illegible]	0.08	0.20	0.03

associated with the urine values (*3*) and the fact that an additional source of tritium intake, i.e., drinking water, is not considered if the DE calculation is based on food intake.

The above calculations are valid for standard man with a body weight of 70 kg and a hydrogen body content of 7,000 grams. The DE to children who actually consumed this food depends upon the body weight and the hydrogen content of the body. An estimate of DE of children may be carried out by the method described elsewhere (*3*).

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SECTION I. MILK AND FOOD

Milk Surveillance, January 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides, and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both

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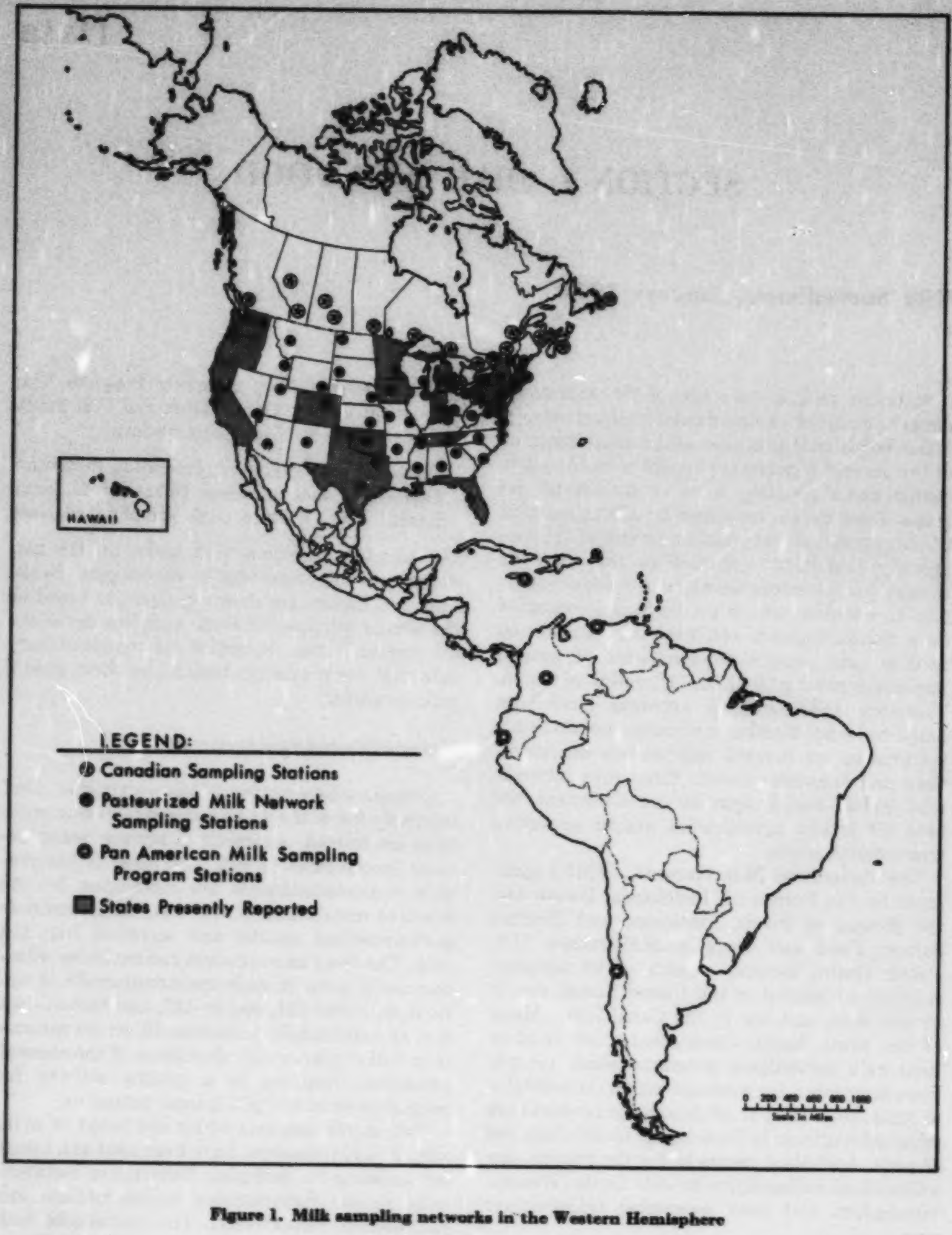
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 15 participated in the experiment.

The iodine-131 and cesium-137 results show much improvement over previous tests. Barium-140 results also look good, which is encouraging, since this is the first time barium-140 was analyzed for this type of experiment. However, strontium-89 and strontium-90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short-time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

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was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[e]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[e]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

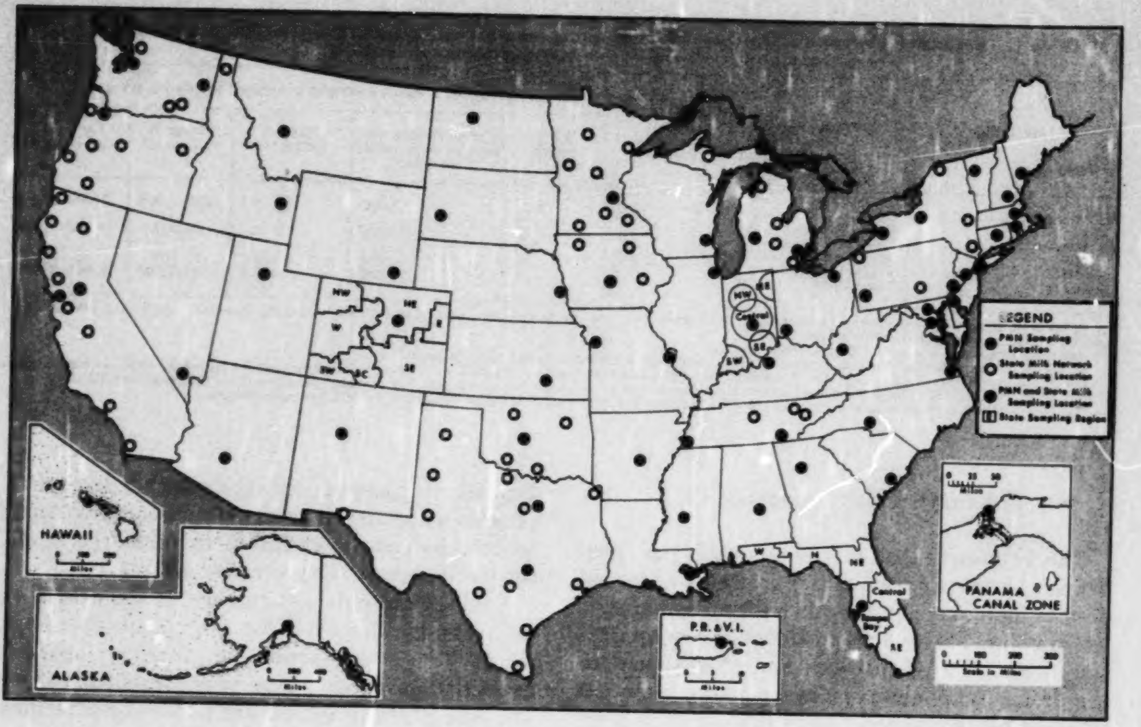
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
E
SW
SC
SE
Central
Miles
Scale in Miles

Figure 2. State and PMN milk sampling locations in the United States

an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for January 1970 and the 12-month period, February 1969 to January 1970. Except where noted, the

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Table 3. Concentration of radionuclides in milk for January 1970 and 12-month period, February 1969 through January 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	3	7	0(4)	0	10(4)	10
Alaska:	Palmer[c]	P	4	6	0(4)	0	7(4)	6
Ariz:	Phoenix[c]	P	2	1	0(5)	0	0(5)	0
Ark:	Little Rock[c]	P	14	16	0(4)	0	18(4)	18
Calif:	Sacramento[c]	P	0	1	0(5)	0	0(5)	0
	San Francisco[c]	P	0	2	0(4)	0	0(4)	0
	Del Norte	P	12	19	0	0	20	21
	Fresno	P	2	2	0	0	2	5
	Humboldt	P	4	5	0	0	6	8
	Los Angeles	P	2	2	0	0	3	3
	Mendocino	P	3	4	0	0	6	5
	Sacramento	P	2	3	0	0	8	5
	San Diego	P	2	2	0	0	1	3
	Santa Clara	P	2	2	0	0	7	5
	Shasta	P	2	3	0	0	4	6
	Sonoma	P	2	3	0	0	13	6
Colo:	Denver[c]	P	7	5	0(4)	0	0(4)	1
	West	R	(d)		NS	(e)	NS	(e)
	Northeast	R	(d)		(e)	(e)	(e)	(e)
	East	R	(d)		(e) (2)	(e)	(e)	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	10	8	0(5)	0	7(5)	11
	Central	P	7	7	0(5)	0	7(5)	11
Del:	Wilmington[c]	P	7	8	0(4)	0	0(4)	6
D.C.:	Washington[c]	P	5	7	0(5)	0	0(5)	4
Fla:	Tampa[c]	P	6	6	0(4)	0	45(4)	54
	West	R	9	13	0	0	14	25
	North	R	7	13	0	0	17	26
	Northeast	R	6	8	0	0	30	54
	Central	R	7	8	0	0	30	56
	Tampa Bay area	R	8	8	0	0	40	56
	Southeast	R	7	8	0	0	59	86
Ga:	Atlanta[c]	P	10	10	0(4)	0	18(4)	19
Hawaii:	Honolulu[c]	P	3	3	0(4)	0	0(4)	0
Idaho:	Idaho Falls[c]	P	6	5	0(4)	0	1(4)	4
Ill:	Chicago[c]	P	7	7	0(4)	0	5(4)	8
Ind:	Indianapolis[c]	P	7	8	0(4)	0	4(4)	5
	Northeast	P	6	10	15	1	15	10
	Southeast	P	9	8	0	0	10	11
	Central	P	6	8	0	0	10	10
	Southwest	P	8	9	0	0	25	13
	Northwest	P	8	10	0	0	15	17
Iowa:	Des Moines[c]	P	7	6	0(4)	0	0(4)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	7	0(4)	0	0(4)	1
Ky:	Louisville[c]	P	6	8	0(4)	0	5(4)	4
La:	New Orleans[c]	P	NS	16	NS	0	NS	18
Maine:	Portland[c]	P	9	11	0(4)	0	20(4)	23
Md:	Baltimore[c]	P	9	8	0(4)	0	1(4)	6
Mass:	Boston[c]	P	5	11	0(4)	0	18(4)	22
Mich:	Detroit[c]	P	10	8	0(4)	0	6(4)	9
	Grand Rapids[c]	P	11	20	0(4)	0	7(4)	13
	Bay City	P	10	9	(e) (2)	(e)	13(2)	8
	Charlevoix	P	13	10	(e) (4)	(e)	14(4)	18
	Detroit	P	9	6	(e) (4)	(e)	6(4)	6
	Grand Rapids	P	8	8	(e) (4)	(e)	11(4)	13
	Lansing	P	8	7	(e) (3)	(e)	16(2)	13
	Marquette	P	13	11	(e) (2)	(e)	19(2)	26
	Monroe	P	8	5	(e) (2)	(e)	0(2)	2
	South Haven	P	NS	7	NS	(e)	NS	10
Minn:	Minneapolis[c]	P	9	10	0(4)	0	0(4)	8
	Bemidji	P	16	17	0	0	24	24
	Mankato	P	3	9	0	0	11	0
	Rochester	P	6	8	0	0	11	0
	Duluth	P	18	19	0	0	23	23
	Worthington	P	4	7	0	0	0	0
	Minneapolis	P	10	12	0	0	22	0
	Fergus Falls	P	5	9	0	0	14	0
	Little Falls	P	6	9	0	0	0	0
Miss:	Jackson[c]	P	16	12	0(5)	0	8(5)	13
Mo:	Kansas City[c]	P	6	7	0(4)	0	0(4)	1
	St. Louis[c]	P	7	8	0(5)	0	0(5)	2
Mont:	Helena[c]	P	6	5	0(4)	0	7(4)	5
Nebr:	Omaha[c]	P	5	6	0(5)	0	0(5)	1
Nev:	Las Vegas[c]	P	3	1	0(4)	0	0(4)	0

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for January 1970 and 12-month period, February 1969 through January 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H.:	Manchester[c]	P	9	8	0(4)	0	17(4)	19
N.J.:	Trenton[c]	P	8	9	0(4)	0	4(4)	7
N. Mex:	Albuquerque[c]	P	2	2	0(4)	0	0(4)	0
N.Y.:	Buffalo[c]	P	7	7	0(3)	0	5(3)	9
	New York City[c]	P	5	10	0(4)	0	8(4)	12
	Syracuse[c]	P	7	7	0(4)	0	14(4)	10
	Albany	P	NS	5	NS	0	NS	(e)
	Buffalo	P	NA	0	0	0	(e)	(e)
	Massena	P	5	8	0(3)	0	(e) (3)	(e)
	Newburg	P	8	8	0	0	(e)	(e)
	New York City	P	7	8	0(6)	0	(e) (6)	(e)
	Syracuse	P	3	4	0(1)	0	(e)	(e)
N.C.:	Charlotte[c]	P	12	12	0(4)	0	11(4)	13
N. Dak:	Minot[c]	P	8	10	0(4)	0	14(4)	13
Ohio:	Cincinnati[c]	P	8	8	0(4)	0	0(4)	3
	Cleveland[c]	P	10	9	0(5)	0	3(5)	6
Okla:	Oklahoma City[c]	P	7	7	0(4)	0	7(4)	9
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	5	6	0(5)	0	0(5)	6
	Baker	P	NA	2	(e)	(e)	(e)	5
	Coos Bay	P	6	6	(e)	(e)	17	12
	Eugene	P	5	4	(e)	(e)	(e)	8
	Medford	P	2	2	(e)	(e)	(e)	13
	Portland composite	P	NA	4	(e)	(e)	7(5)	6
	Portland local	P	4	5	(e)	(e)	12(4)	9
	Redmond	P	NA	2	(e)	(e)	21	3
	Tillamook	P	4	6	(e)	(e)	15	14
Pa:	Philadelphia[c]	P	9	9	0(4)	0	4(4)	4
	Pittsburgh[c]	P	5	11	0(4)	0	6(4)	8
	Dauphin	P	8	7	11	1	26	14
	Erie	P	7	10	15	6	25	22
	Philadelphia	P	8	7	0	5	0	8
	Pittsburgh	P	10	10	0	2	17	18
R.I.:	Providence[c]	P	9	9	0(4)	0	15(4)	16
S.C.:	Charleston[c]	P	7	10	0(4)	0	20(4)	23
S. Dak:	Rapid City[c]	P	9	8	0(5)	0	2(5)	5
Tenn:	Chattanooga[c]	P	10	10	0(4)	0	14(4)	13
	Memphis[c]	P	10	8	0(4)	0	5(4)	5
	Chattanooga	P	9	13	0(3)	0	11(3)	15
	Clinton	P	10	15	0	1	15	14
	Knoxville	P	6	10	0(2)	0	7(2)	5
	Nashville	P	7	8	0	0	0	4
Tex:	Austin[c]	P	3	2	0(3)	0	4(3)	4
	Dallas[c]	P	2	6	0(4)	0	3(4)	6
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	5	6	0	0	10	5
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	10	8	0	0	15	15
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	2	2	0	0	0	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	10	NS	0	NS	13
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	NS	6	NS	0	NS	8
Utah:	Salt Lake City[c]	P	3	4	0(4)	0	5(4)	4
Vt:	Burlington[c]	P	9	8	0(4)	0	6(4)	13
Va:	Norfolk[c]	P	9	10	0(5)	0	10(5)	8
Wash:	Seattle[c]	P	3	7	0(4)	0	1(4)	11
	Spokane[c]	P	5	6	0(4)	0	0(4)	4
	Benton County	R	0	1	0	0	14	7
	Franklin County	R	NS	0	NS	0	NS	0
	Sandpoint, Idaho	R	12	11	0	0	17	27
	Skagit County	R	6	7	0	0	0	13
W. Va:	Charleston[c]	P	9	9	0(4)	0	7(4)	7
Wisc:	Milwaukee[c]	P	6	7	0(5)	0	10(5)	11
Wyo:	Laramie[c]	P	7	6	0(4)	0	0(4)	4
CANADA:								
Alberta:	Calgary	P	8	8	(d)		21	16
	Edmonton	P	6	7	(d)		21	14
British Columbia:	Vancouver	P	8	11	(d)		30	31
Manitoba:	Winnipeg	P	8	8	(d)		22	25
New Brunswick:	Fredericton	P	10	13	(d)		21	17
Newfoundland:	St. Johns	P	16	17	(d)		27	33

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for January 1970 and 12-month period, February 1969 through January 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Nova Scotia:	Halifax	P	10	10	(d)		16	10
Ontario:	Ft. William	P	12	15	(d)		30	30
	Ottawa	P	6	8	(d)		9	13
	Sault Ste. Marie	P	11	15	(d)		19	29
	Toronto	P	6	5	(d)		10	10
	Windsor	P	7	6	(d)		15	11
Quebec:	Montreal	P	8	8	(d)		19	18
	Quebec	P	11	11	(d)		23	25
Saskatchewan:	Regina	P	5	7	(d)		12	12
	Saskatoon	P	7	8	(d)		6	12
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	2	2	0	0	10	3
Chile:	Santiago	P	0	0	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	4	4	0	0	45	86
Venezuela:	Caracas	P	2	2	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	0	0(4)	0	9(4)	9
Puerto Rico:	San Juan[c]	P	3	3	0(4)	0	8(4)	7
PMN network average[f]			7	7	0	0	6	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for January 1970 were below the respective practical reporting levels. Averages for those stations at which strontium-89 was detected were Del Norte, Calif., 8 pCi/liter; Minot, N. Dak., 9 pCi/liter; and Dallas, Tex., 6 pCi/liter.

Iodine-131 results are included in the table even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for the month of January 1970, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif., and Duluth, Minn.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 59 pCi/liter in the United States for the month of January 1970, and the highest 12-month average was 86 pCi/liter (Southeast Florida) representing 2.4 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level except Dauphin, Pa., 11 pCi/liter and Erie, Pa., 15 pCi/liter.

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Acknowledgment

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational, and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
Connecticut Diet Study	July–December 1968, and January–June 1969	February 1970
Radionuclides in Institutional Diet Samples, *PHS*	April–June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August–December 1968	December 1969

1. Estimated daily intake of radionuclides in California diets, October–December 1968 and January–March 1969

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians since January 1964 (*1*).

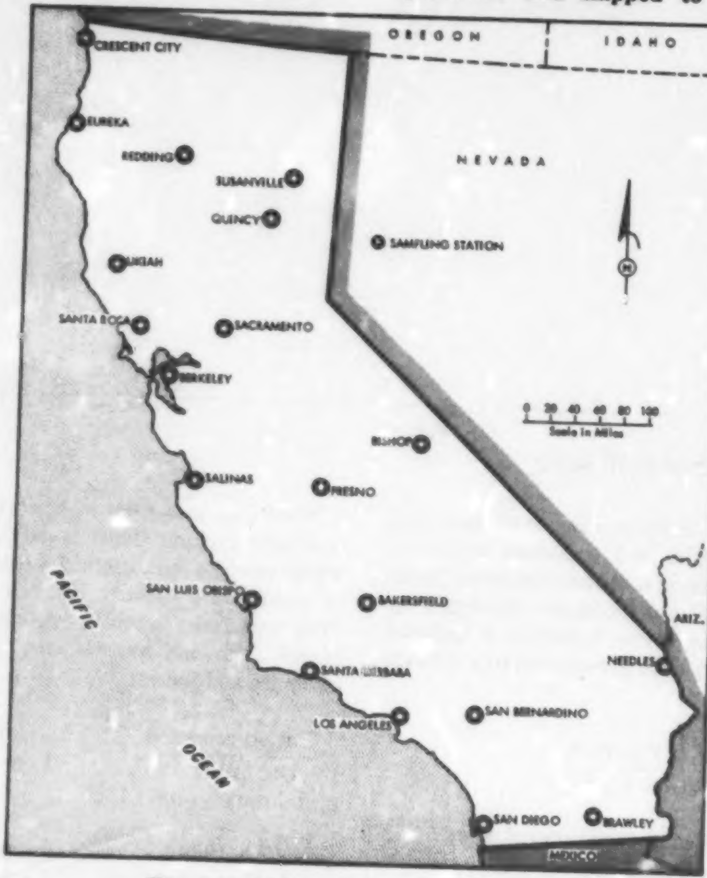
It is recognized that a "standard" or "typical" diet does not exist because of variations in individual tastes, therefore an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 3 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and


OREGON
IDAHO
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
NEVADA
SAMPLING STATION
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UKIAH
SANTA ROSA
SACRAMENTO
BERKELEY
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
PACIFIC
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
SANTA BARBARA
LOS ANGELES
SAN BERNARDINO
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 1. California diet sampling stations

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Table 1. Estimated daily intake of radionuclides in California diets[a], October–December 1968

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)				Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	K[c]	Na	Ca
Bakersfield	2.07	0	4	0.8	27	3.0	3.8	1.1
Berkeley	2.26	0	5	1.1	19	3.0	3.4	1.0
Bishop	1.41	0	4	.9	12	2.2	2.3	.8
Brawley	2.09	0	7	1.3	11	2.9	3.9	1.2
Crescent City	2.32	0	13	1.4	42	3.4	3.8	.9
Eureka	2.35	0	7	1.4	24	2.8	4.3	.9
Fresno	NS							
Los Angeles	1.60	0	5	1.1	19	2.1	2.9	.6
Needles	2.18	0	5	1.1	20	2.8	3.2	.9
Quincy	2.12	0	34	2.9	17	3.5	3.4	1.6
Redding	2.34	[d]3.1	4	1.3	11	3.2	3.0	.8
Sacramento	2.35	0	6	1.2	12	2.7	4.4	1.0
Salinas	2.25	[d]1.5	4	1.1	17	3.2	4.9	.8
San Bernardino	1.47	[d]3.7	4	.9	12	2.2	3.5	.8
San Diego	1.52	0	5	.7	15	2.5	2.4	.9
San Luis Obispo	1.96	0	5	1.8	14	3.5	4.4	1.4
Santa Barbara	1.88	0	5	1.2	16	2.2	2.9	.8
Santa Rosa	1.75	0	4	.7	11	2.2	2.2	1.1
Susanville	1.91	0	4	.8	17	2.4	3.2	.8
Ukiah	1.86	[d]2.2	4	2.0	20	3.0	3.3	1.2

[a] Based on analyses of Hospital Standard Diets located in listed cities. Zirconium-95, manganese-54, and cerium-141, -144, were zero during this period.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.

[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported in the best available estimate, but is not statistically significant.

NS, no sample.

Table 2. Estimated daily intake of radionuclides in California diets[a], January–March 1969

City	Consumption (kg/capita-day[b])	Intake (pCi/capita-day)				Intake (g/capita-day)		
		^{89}Sr[c]	^{90}Sr	^{226}Ra	^{137}Cs	K[d]	Na	Ca
Bakersfield	2.25	0	7	0.2	8	3.1	5.7	1.3
Bishop	1.62	0	7	1.0	9	2.4	2.8	1.2
Brawley	2.30	0	8	1.4	10	3.4	4.4	1.1
Crescent City	2.52	0	15	.6	22	3.4	4.3	1.6
Eureka	2.25	0	6	.8	18	2.7	4.2	.7
Fresno	2.33	0	7	1.1	10	3.7	3.8	1.4
Los Angeles	1.90	0	5	1.1	19	2.3	3.2	.5
Needles	2.34	0	6	.4	7	2.9	3.0	1.0
Quincy	2.15	0	6	.7	15	3.0	3.0	.7
Redding	2.36	0	11	.9	18	2.7	3.1	2.1
Sacramento	2.53	0	8	1.4	15	3.2	5.0	1.3
Salinas	2.49	0	6	1.2	8	3.3	5.6	.8
San Bernardino	1.93	0	11	1.4	15	3.0	4.2	1.1
San Diego	2.35	0	6	1.2	15	3.6	3.9	1.2
San Luis Obispo	2.08	0	7	1.0	14	3.1	4.3	1.2
Santa Barbara	2.20	0	14	1.7	11	2.7	3.1	1.8
Santa Rosa	1.82	0	7	1.5	9	2.1	3.0	1.2
Susanville	1.87	0	4	.8	15	2.6	2.7	.9
Ukiah	1.92	0	15	2.3	10	2.9	3.5	1.2

[a] Based on analyses of Hospital Standard Diets located in listed cities. Zirconium-95, manganese-54, and cerium-141, -144, were zero during this period.

[b] Kilograms of food per person per day in this diet.

[c] Practical reporting levels are: strontium-89, 2 pCi/capita-day; zirconium-niobium-95, 7 pCi/capita-day; manganese-54, 7 pCi/capita-day; cerium-141–144, 10 pCi/capita-day.

[d] Natural potassium contains 0.0119 percent of radioactive potassium-40.

Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After being weighed at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, stable calcium, and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (October–December 1968), table 2 (January–March 1969).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through March 1969 is given in figures 2 and 3.

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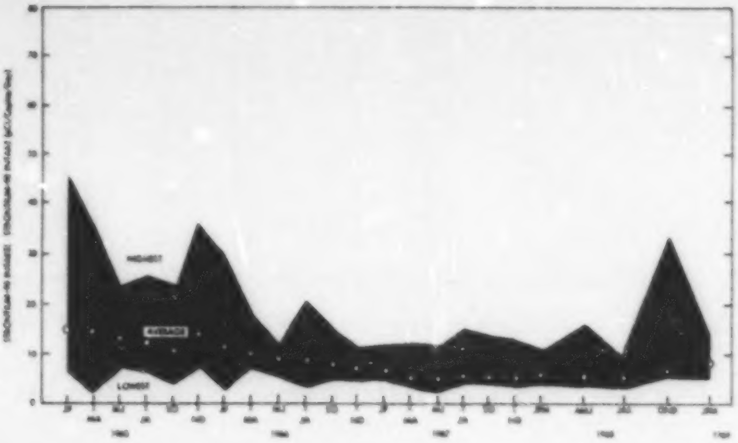

Figure 2. Averages and ranges of daily strontium-90 intake in California diets, 1965–March 1969

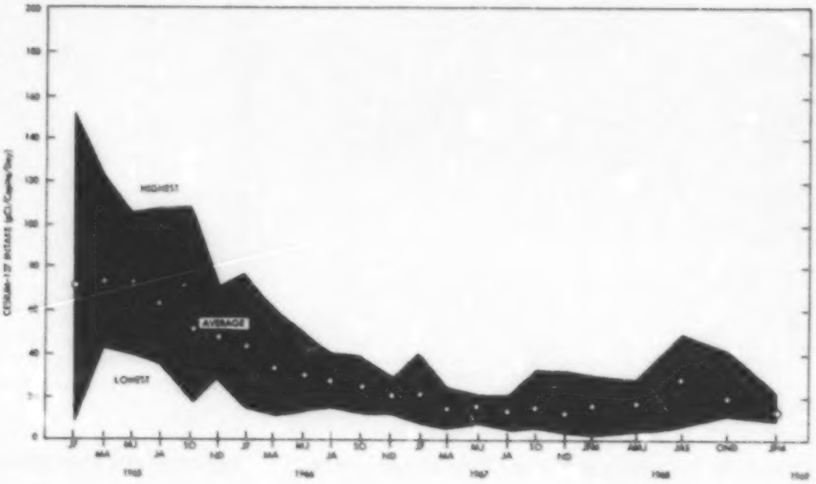

Figure 3. Averages and ranges of daily cesium-137 intake in California diets, 1965–March 1969

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–October 1967	May 1968
November–December 1967, and January–September 1968	May 1969

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Colorado River Basin	1967	December 1968
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	April–June 1968	October 1969

1. Radiation Alert Network
January 1970

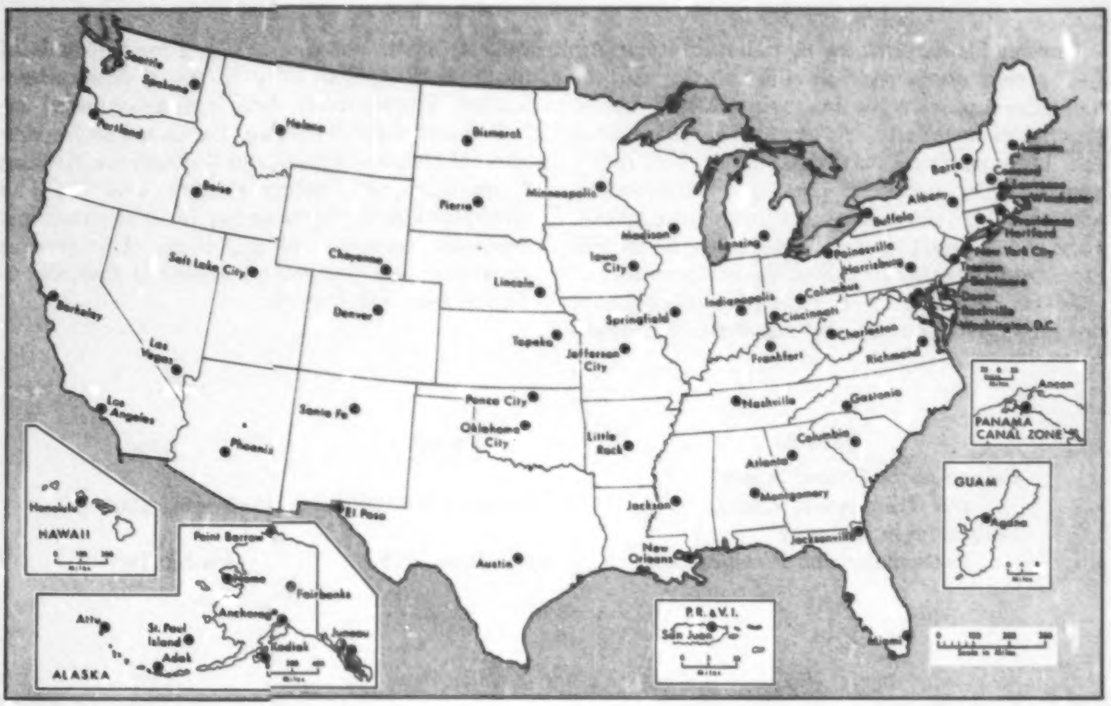
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during January 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.


Seattle
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Minneapolis
Salt Lake City
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Denver
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Jefferson City
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Madison
Iowa City
Springfield
Lansing
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Painesville
Harrisburg
Buffalo
Albany
Barre
Concord
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Hartford
Richmond
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1970

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
			Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Field estimation of deposition		
									Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	3	0	1	Dec 69	5	90	5	90	63
Alaska:	Adak	(b)				Dec 69	(c)				
	Anchorage	19	0	0	0	Aug 69	(c)				
	Attu Island	5	4	0	1	Jan 70	(c)				
	Fairbanks	20	1	0	0	Sept 69	3	6	3	6	2
	Juneau	(b)				Oct 69	(c)				
	Kodiak	(b)				Nov 69	(c)				
	Nome	2	1	1	1	Mar 70	(c)				
	Point Barrow	(b)				Feb 70	(c)				
	St. Paul Island	(b)				Apr 70	(c)				
Ariz:	Phoenix	20	14	3	9	Oct 69	(c)				
Ark:	Little Rock	9	3	0	0	Aug 69	(c)				
Calif:	Berkeley	21	1	0	0	Nov 69	10	250	10	250	0
	Los Angeles	21	3	0	1	Mar 70	(c)				
C.Z:	Ancon	16	1	0	0	Nov 69	(c)				
Colo:	Denver	20	7	1	2	Nov 69	(c)				
Conn:	Hartford	20	0	0	0	Sept 69	5	20	5	20	0
Del:	Dover	20	1	0	0	May 70	(c)				
D.C:	Washington	23	2	0	0	Feb 70	(c)				
Fla:	Jacksonville	13	0	0	0	Aug 69	4	79	4	32	11
	Miami	18	0	0	0	Sept 69	4	58	4	58	0
Ga:	Atlanta	21	1	1	1	Apr 70	1	80	1	80	40
Guam:	Agana	(b)				May 70	(c)				
Hawaii:	Honolulu	23	1	0	0	Jan 70	3	32	(d)		
Idaho:	Boise	21	1	0	0	Jan 70	14	122	14	122	23
Ill:	Springfield	17	1	0	0	Feb 70	(c)				
Ind:	Indianapolis	(b)				Apr 70	(c)				
Iowa:	Iowa City	20	1	0	0	Nov 69	1	11	1	11	0
Kans:	Topeka	20	3	0	1	Aug 69	1	4	1	4	0
Ky:	Frankfort	9	4	1	2	Feb 70	(c)				
La:	New Orleans	13	1	0	0	Feb 70	5	100	(d)		
Maine:	Augusta	21	0	0	0	Mar 70	6	20	6	20	0
Md:	Baltimore	20	1	0	0	Sept 69	3	13	3	13	0
	Rockville	12	2	0	1	Jan 70	(c)				
Mass:	Lawrence	19	0	0	0	May 70	2	10	2	10	0
	Winchester	21	1	0	0	Dec 69	4	17	4	17	0
Mich:	Lansing	18	0	0	0	Jan 70	(c)				
Minn:	Minneapolis	21	0	0	0	May 70	2	5	2	5	1
Miss:	Jackson	16	1	0	0	Mar 70	1	8	1	8	0
Mo:	Jefferson City	20	1	0	0	Apr 70	1	3	1	3	0
Mont:	Helena	21	7	0	1	Dec 69	1	5	1	5	0
Nebr:	Lincoln	13	5	0	1	Apr 70	(c)				
Nev:	Las Vegas	12	6	0	1	Sept 69	(c)				
N.H:	Concord	(b)				Feb 70	(c)				
N.J:	Trenton	21	0	0	0	Mar 70	4	17	4	17	0
N. Mex:	Santa Fe	18	2	0	1	Dec 69	(c)				
N.Y:	Albany	2	1	0	0	Apr 70	1	7	1	7	4
	Buffalo	22	0	0	0	Nov 69	(c)				
	New York City	19	1	0	0	Dec 69	(c)				
N.C:	Gastonia	16	6	1	2	Nov 69	3	17	(d)		
N. Dak:	Bismarck	21	1	0	0	Feb 70	6	8	6	8	0
Ohio:	Cincinnati	(b)				May 70	(c)				
	Columbus	2	0	0	0	Mar 70	(c)				
	Painesville	15	0	0	0	Sept 69	6	17	6	17	7
Okla:	Oklahoma City	19	4	0	1	Jan 70	1		1	7	0
	Ponca City	21	4	0	2	Sept 69	(c)				
Ore:	Portland	(b)				Apr 70	(c)				
Pa:	Harrisburg	16	0	0	0	Apr 70	3	25	3	25	7
P.R:	San Juan	(b)				Mar 70	(c)				
R.I:	Providence	10	1	0	0	Jan 70	(c)				
S.C:	Columbia	15	5	0	1	Dec 69	5	64	5	64	4
S. Dak:	Pierre	2	2	1	2	Oct 69	(c)				
Tenn:	Nashville	20	1	0	0	Jan 70	3	25	3	24	0
Tex:	Austin	4	8	2	4	May 70	(c)				
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	31	2	0	1	Mar 70	6	16	6	16	2
Vt:	Barre	16	1	0	0	Aug 69	2	5	2	5	1
Va:	Richmond	20	1	0	0	Aug 69	3	16	3	16	3
Wash:	Seattle	16	0	0	0	Aug 69	12	150	(d)		
	Spokane	21	0	0	0	May 70	(c)				
W. Va:	Charleston	19	2	0	1	Dec 69	6	23	6	23	2
Wisc:	Madison	21	0	0	0	Aug 69	5	15	5	13	2
Wyo:	Cheyenne	17	3	0	1	Sept 69	1	22	1	22	7
Network summary		1,030	14	0	1		4	38	4	32	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samp es received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

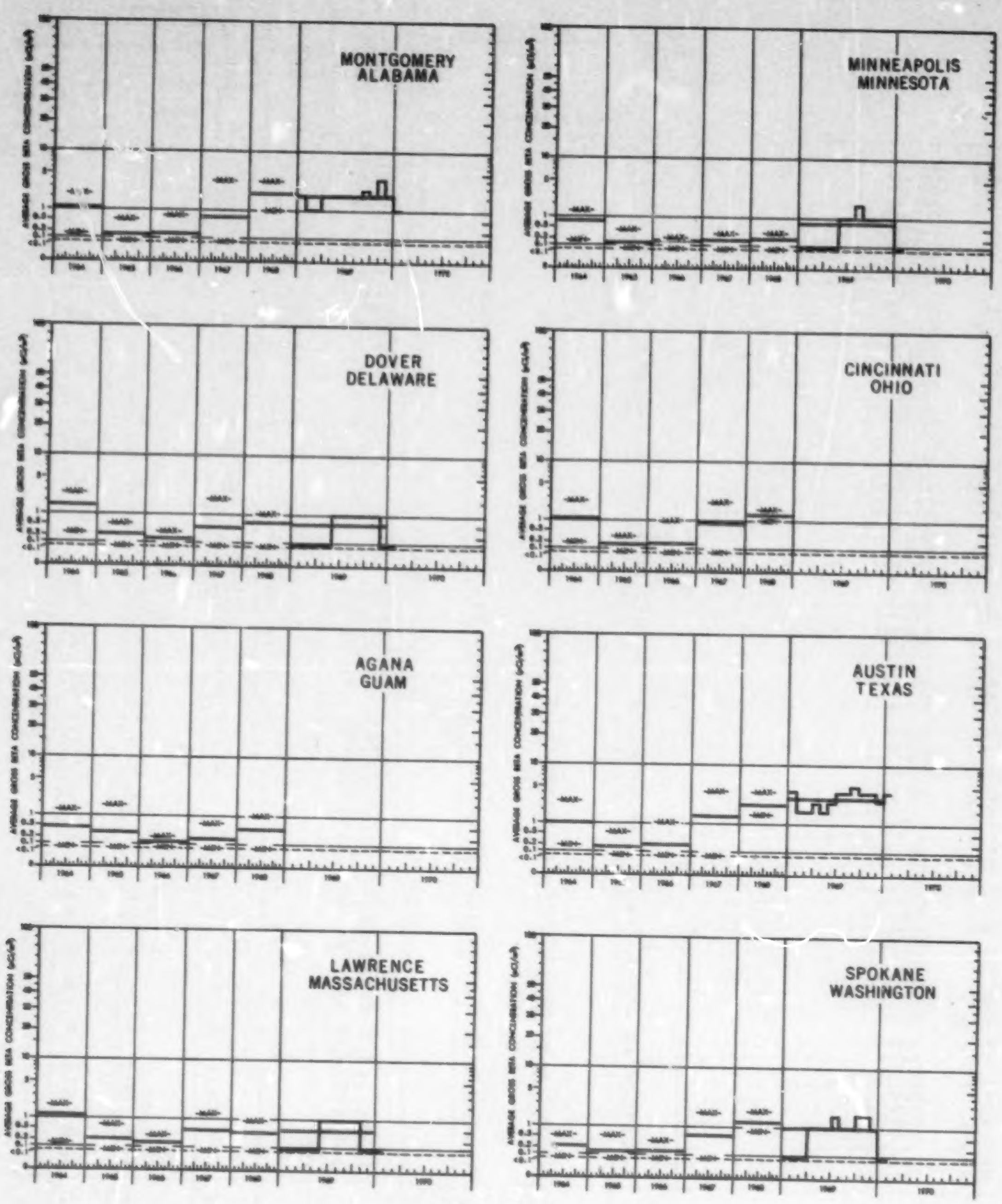

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–January 1970

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2. Canadian Air and Precipitation Monitoring Program[1], January 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for January 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, January 1970

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.2	0.0	0.1	11	0.1
Coral Harbour	13	.1	.0	.1	527	1.7
Edmonton	31	.1	.0	.1	24	.4
Ft. Churchill	30	.1	.0	.1	21	.2
Fredericton	30	.1	.0	.1	12	.2
Goose Bay	30	.1	.0	.0	12	.4
Halifax	31	.2	.0	.1	8	.3
Inuvik	31	.1	.0	.1	90	.6
Montreal	31	.1	.0	.1	52	1.0
Moosonee	31	.1	.0	.1	12	.3
Ottawa	31	.1	.0	.1	16	.5
Quebec	31	.1	.0	.1	16	.7
Regina	31	.1	.0	.1	18	.3
Resolute	30	.1	.0	.1	35	.1
St. John's, Nfld	30	.1	.0	.0	7	.5
Saskatoon	31	.1	.0	.1	37	.3
Sault St. Marie	31	.1	.0	.1	25	1.7
Thunder Bay[a]	31	.1	.0	.1	18	.8
Toronto	31	.2	.0	.1	42	1.2
Vancouver	31	.1	.0	.0	21	2.2
Whitehorse	31	.1	.0	.0	26	.4
Windsor	31	.1	.0	.1	30	1.5
Winnipeg	31	.1	.0	.1	27	.6
Yellowknife	30	.1	.0	.1	32	.3
Network summary	720	0.2	0.0	0.1	47	0.7

[a] Effective January 1, 1970, the City of Fort William officially changed its name to Thunder Bay.

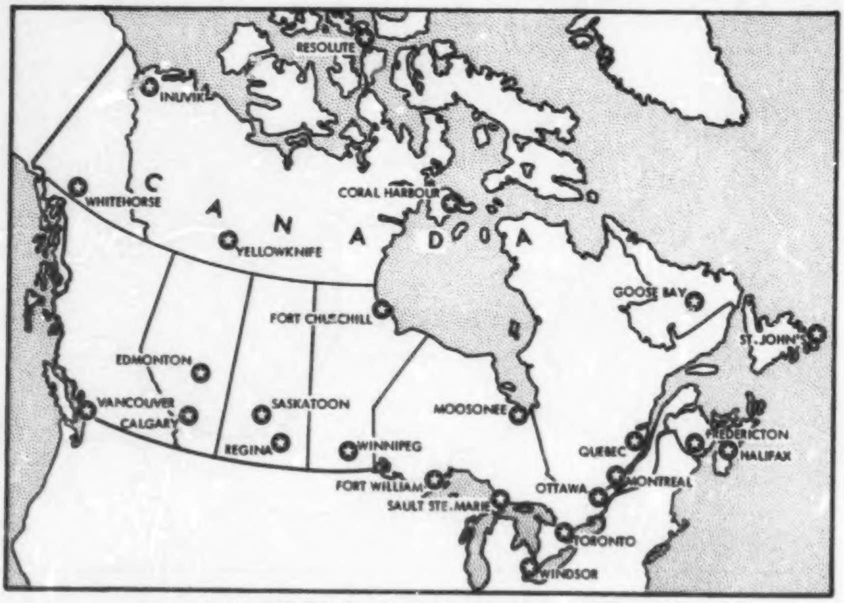
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Mexican Air Monitoring Program
November 1969

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of México was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during November 1969 is presented in table 3.

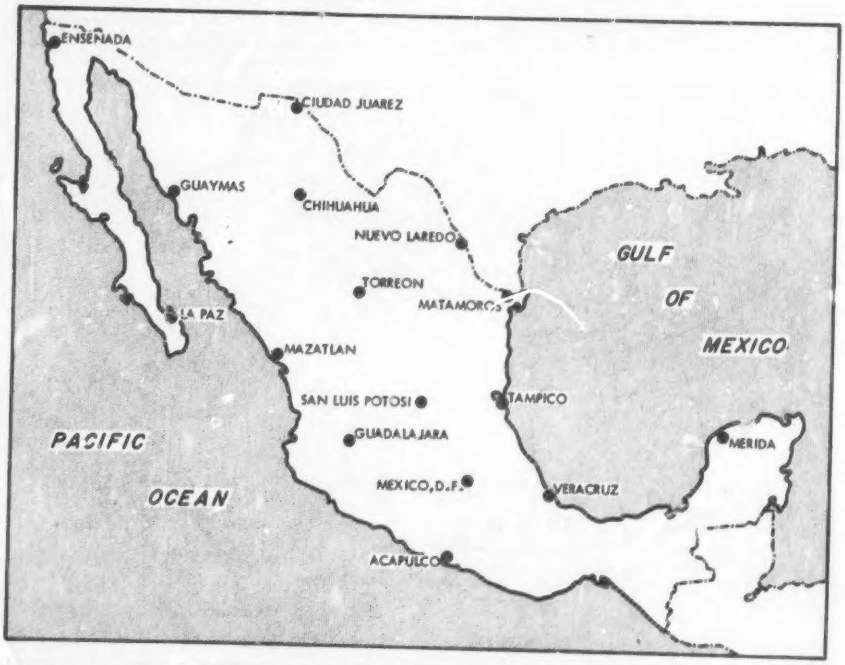

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, November 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	9	0.1	<0.1	0.1
Chihuahua	12	.3	.1	.1
Ciudad Juarez	NS			
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	15	.2	.1	.1
Matamoros	NS			
Mazatlan	NS			
Mérida	4	.2	<.1	.2
México, D.F.	7	.1	<.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	10	.3	.1	.2
Veracruz	NS			

NS, no sample, station temporarily shutdown.

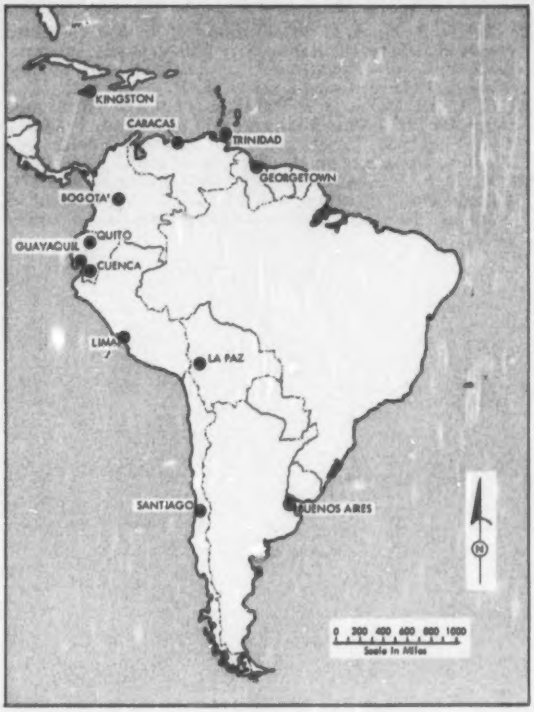

Figure 5. Pan American Sampling Program stations

4. Pan American Air Sampling Program January 1970

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports.* The January 1970 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, January 1970

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Argentina:				
Buenos Aires	16	0.17	0.02	0.09
Bolivia:				
La Paz	10	.06	.00	.03
Chile:				
Santiago	27	.24	.03	.09
Colombia:				
Bogota	19	.05	.00	.02
Ecuador:				
Cuenca	NS	NS	NS	NS
Guayaquil	18	.07	.02	.04
Quito	NS	NS	NS	NS
Guyana:				
Georgetown	NS	NS	NS	NS
Jamaica:				
Kingston	8	.13	.03	.07
Peru:				
Lima	17	.16	.05	.08
Venezuela:				
Caracas	10	.15	.00	.07
West Indies:				
Trinidad	18	.06	.02	.04
Pan American summary	143	0.24	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

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(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, April-June 1969[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

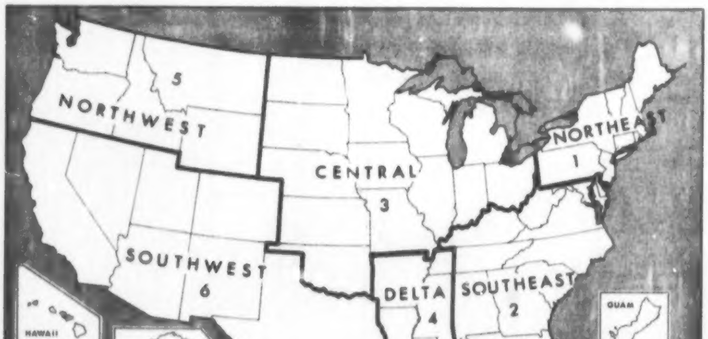

Figure 1. Georgraphical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, April–June 1969

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
New Jersey	V	1	F	70.9± 7.5	17.3	4.09
New York	V	5	F	77.0± 7.9	27.7	2.77
Pennsylvania	V	6	F	65.3± 7.0	27.7	2.35
New York	V	8	F	84.3±10.0	34.2	2.46
	V	11	M	76.3± 6.9	29.4	2.59
	V	13	M	40.4± 5.3	13.8	2.92
	V	13	M	79.9± 8.3	42.6	1.87
	V	15	M	87.8± 9.7	38.4	2.28
	V	17	M	105.0±10.0	48.4	2.16
Vermont	V	17	M	80.5± 9.3	52.7	1.52
	V	18	F	114.0±12.0	56.7	2.01
	V	18	M	148.0±12.0	47.4	3.12
New York	V	18	M	87.8± 7.0	48.2	1.82
	V	19	M	53.4± 5.7	25.4	2.10
Vermont	V	20	M	73.9± 6.7	46.9	1.57
	V	20	M	120.0± 9.9	54.0	2.22
New York	V	21	M	87.8± 9.7	54.5	1.61
Massachusetts	V	22	F	203.0±18.0	68.4	2.96
New York	V	22	M	106.0±13.0	45.7	2.31
Southeast:						
South Carolina	V	1	M	102.0±12.0	29.1	3.50
Maryland	V	2	M	94.1±10.0	33.9	2.77
	V	5	F	63.1± 9.8	30.7	2.05
South Carolina	V	8	F	149.0±11.0	39.8	3.74
Maryland	V	9	M	68.4± 8.5	27.2	2.51
South Carolina	V	9	F	113.0± 9.7	32.6	3.46
Maryland	V	10	M	78.5±10.0	35.9	2.19
	V	10	M	63.6± 9.7	36.4	1.74
South Carolina	V	11	F	161.0±15.0	57.2	2.81
Georgia	V	11	M	126.0± 9.2	31.0	4.06
South Carolina	V	12	M	166.0± 9.9	40.6	4.08
	V	13	M	88.0± 8.5	39.7	2.21
Maryland	V	14	F	123.0±12.0	52.8	2.32
South Carolina	V	15	F	130.0±13.0	48.4	2.68
Maryland	V	15	F	104.0±12.0	47.6	2.18
	V	15	M	135.0±13.0	55.7	2.42
South Carolina	V	15	M	151.0±10.0	45.9	3.28
Maryland	V	16	M	110.0±10.0	47.9	2.29
	V	16	M	80.9±10.0	45.3	1.78
Georgia	V	17	F	111.0±10.0	46.5	2.38
Maryland	V	17	M	116.0± 9.1	49.5	2.34
	V	18	M	147.0±13.0	62.7	2.34
South Carolina	V	18	F	130.0± 9.1	45.8	2.83
	V	18	M	174.0±12.0	48.6	3.58
	V	18	M	107.0± 9.3	48.5	2.20
Maryland	V	18	M	109.0±11.0	52.5	2.07
	V	18	M	168.0±14.0	62.7	2.67
South Carolina	V	18	M	101.0±10.0	47.4	2.13
Maryland	V	19	M	93.1±10.0	63.0	1.47
	V	19	M	81.7±10.0	46.3	1.76
	V	19	M	53.3± 6.3	50.3	1.06
	V	19	F	108.0±11.0	50.6	2.13
	V	20	M	130.0± 9.5	53.3	2.43
	V	20	F	73.1±10.0	51.5	1.41
	V	20	M	110.0±10.0	67.9	1.62
	V	20	M	160.0±12.0	61.1	2.61
	V	20	M	120.0±15.0	58.2	2.06
	V	20	M	95.1± 9.5	50.2	1.89
	V	20	M	88.5±10.0	57.3	1.54
	V	20	M	86.1± 9.7	52.5	1.64
	V	21	M	114.0±12.0	52.0	2.19
	V	21	M	90.9± 9.8	57.9	1.56
	V	22	M	156.0±14.0	55.3	2.82
	V	22	M	106.0±11.0	56.3	1.88
	V	22	M	75.9±10.0	50.3	1.50
	V	22	M	129.0±13.0	53.3	2.42
	V	23	M	172.0±13.0	59.7	2.88
	V	23	F	89.1±11.0	42.8	2.08
	V	23	M	222.0±18.0	66.8	3.32
	V	23	F	103.0±12.0	48.6	2.11
	V	24	M	74.5±11.0	44.2	1.68
	V	24	M	80.4±9.5	44.1	1.82
	V	24	M	10.4± 1.3	45.8	.22
	V	25	M	132.0±12.0	54.6	2.41
Central:						
Wisconsin	V	1	M	51.8± 6.7	31.6	1.63
Ohio	V	2	M	65.7±10.0	30.6	2.14
	V	3	F	36.0± 6.3	21.8	1.65
	V	3	F	74.3± 8.7	32.2	2.30
	V	4	M	98.7±11.0	33.8	2.92
	V	4	M	38.9± 5.2	27.9	1.39
Wisconsin	V	5	M	103.0± 9.1	31.5	3.26
Michigan	V	10	F	83.3± 7.8	46.7	1.78
Ohio	V	11	M	67.5± 9.7	41.4	1.63
	V	11	F	59.5± 7.9	42.0	1.38
	V	12	M	88.1± 8.2	48.1	1.83
Wisconsin	V	13	M	52.4± 6.9	31.3	1.67
Ohio	V	14	M	77.9± 7.0	35.3	2.20
	V	15	M	142.0±10.0	55.0	2.58
	V	16	M	113.0±10.0	57.7	1.96
	V	16	M	90.5± 7.6	41.6	2.17

See footnotes at end of table.

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Table 1. Strontium-90 in human bone, April–June 1969—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Iowa	V	16	M	98.0± 8.8	53.5	1.83
	V	16	M	116.0±11.0	52.3	2.21
	V	17	M	154.0±15.0	58.7	2.62
	V	17	M	113.0±11.0	65.2	1.73
	V	18	F	119.0± 9.8	48.0	2.47
	V	18	M	107.0±10.0	47.4	2.25
	V	18	M	44.5± 8.3	50.6	.87
Michigan	V	19	F	103.0±13.0	56.6	1.81
Iowa	V	20	F	225.0±18.0	57.5	3.91
Ohio	V	20	M	80.7± 8.7	53.7	1.50
Nebraska	V	20	M	82.8± 7.2	46.2	1.79
Ohio	V	22	F	103.0± 8.6	46.0	2.23
	V	22	M	73.1± 9.7	59.3	1.23
	V	24	M	52.3± 7.1	47.9	1.09
Delta:						
Louisiana	R	8	M	154.0±13.0	45.5	3.38
Northwest:						
Washington	V, I	1	M	64.6± 9.1	27.2	2.37
Northwest:						
Oregon	V	5	F	53.2± 7.9	30.5	1.74
	V	6	F	76.1± 9.8	55.2	1.37
Washington	V	13	M	66.4± 7.3	36.6	1.81
Oregon	V	16	M	56.8± 6.0	39.2	1.44
	V	17	M	77.8±10.0	45.7	1.70
	V	18	M	101.0± 7.3	39.9	2.53
	V	19	F	83.7±10.0	64.4	1.29
	V	21	F	58.1± 6.3	42.8	1.35
	V	22	F	78.3± 9.9	49.3	1.58
	V	22	M	60.6± 6.5	28.5	2.12
	V	24	M	67.9±10.0	46.1	1.47
	V	25	F	69.3±11.0	54.1	1.28
Southwest:						
Texas	V	1	M	149.0±13.0	32.7	4.55
	V	4	F	63.8± 6.8	30.1	2.11
Colorado	V	17	M	78.0± 7.2	42.6	1.83
	V	18	F	132.0±14.0	58.1	2.27
	V	20	M	114.0±11.0	54.1	2.10
	V	20	F	72.2± 9.4	56.9	1.26
	V	21	M	94.3±13.0	50.4	1.87
California	T	21	M	112.0±10.0	105.0	1.06
Colorado	V	21	M	82.1± 9.4	46.9	1.75
	V	23	M	61.2± 6.7	48.4	1.26
California	V	23	M	14.0± 6.3	39.9	.35
Texas	V	23	F	65.1± 9.5	47.8	1.36
Colorado	V	25	M	69.8±10.0	57.4	1.21
North:						
Alaska	V	1	M	88.1±10.0	29.7	2.96
	V	1	F	94.5±10.0	27.4	3.44
	V	5	F	58.7± 8.1	34.0	1.72
	R	14	M	225.0±34.0	139.0	1.61
	R	22	F	188.0±31.0	133.0	1.41

[a] V, vertebrae; R, rib; I, ilium; T, tibia.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

The analytical results for strontium-90 in individual bones from persons dying during the second quarter (April–June) of 1969 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

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Recent coverage in *Radiological Health Data and Reports:*

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July–September 1968	September 1969
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January–March 1969	March 1970

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Area and the Savannah River Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Oak Ridge Area[2]

January–June 1969

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are concentrated by evaporation and disposed of in deep wells. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average radioactivity concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January–June 1969 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.49 pCi/m^3, the minimum was less than 0.01 pCi/m^3, and the average was 0.02 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak

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[2] Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, (Report Period, January–June 1969). Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

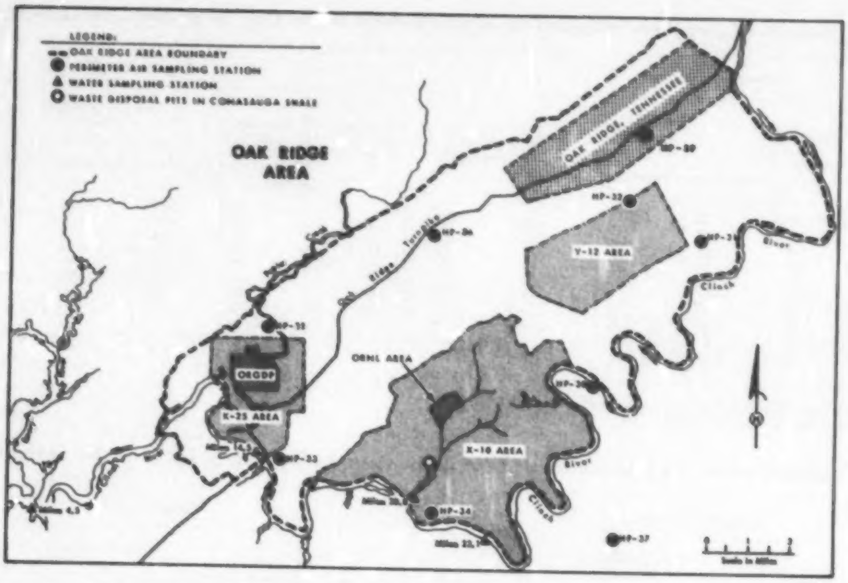
LEGEND:
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
HP-30
HP-32
Y-12 AREA
Clinch
River
Oak Ridge Turnpike
ORGDP
K-25 AREA
ORNL AREA
X-10 AREA
HP-33
HP-34
HP-37
Scale in Miles

Figure 1. Oak Ridge Area—environmental sampling locations

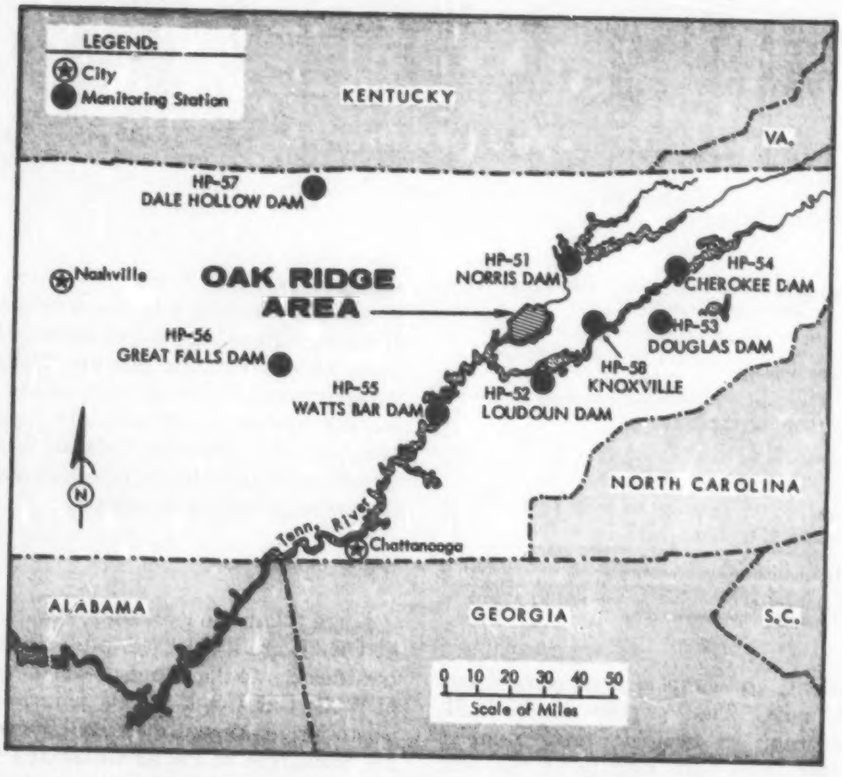
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-56
GREAT FALLS DAM
HP-58
KNOXVILLE
HP-55
WATTS BAR DAM
HP-52
LOUDOUN DAM
NORTH CAROLINA
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50
Scale of Miles

Figure 2. Remote air monitoring stations, Oak Ridge Area

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Table 1. Long-lived gross beta radioactivity of particulates in air, Oak Ridge Area, January–June 1969

Perimeter stations						Remote stations					
Station number (figure 1)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	26	0.38	0.011	0.15	0.15	HP-51	26	0.36	0.062	0.16	0.16
HP-32	26	.47	.029	.18	.18	HP-52	26	.44	.036	.16	.16
HP-33	26	.31	< .001	.13	.13	HP-53	26	.45	.041	.16	.16
HP-34	26	.50	.019	.16	.16	HP-54	25	.35	.024	.14	.14
HP-35	26	.45	.047	.16	.16	HP-55	26	.44	.008	.14	.14
HP-36	127[b]	.41	.051	.18	.18	HP-56	26	.45	.029	.16	.16
HP-37	26	.36	.017	.14	.14	HP-57	26	.43	.008	.16	.16
HP-38	26	.43	.039	.17	.17	HP-58	25	.44	.042	.18	.18
HP-39	26	.49	.027	.18	.18						
Summary	335	0.50	<0.001	0.16	0.16		206	0.45	0.008	0.16	0.16

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m³.
[b] Sampling frequency—5 days per week.

Table 2. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge Area, January–June 1969

Perimeter stations						Remote stations					
Station number (figure 1)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	26	0.005	<0.001	0.002	0.10	HP-51	26	0.004	<0.001	0.001	0.05
HP-32	26	.007	< .001	.002	.10	HP-52	26	.004	< .001	.001	.05
HP-33	26	.004	< .001	.001	.05	HP-53	26	.002	< .001	.001	.05
HP-34	26	.002	< .001	.001	.05	HP-54	25	.006	< .001	.001	.05
HP-35	26	.007	< .001	.002	.10	HP-55	26	.006	< .001	.001	.05
HP-36	127[b]	.008	< .001	.003	.15	HP-56	26	.002	< .001	.001	.05
HP-37	26	.005	< .001	.001	.05	HP-57	26	.002	< .001	.001	.05
HP-38	26	.002	< .001	.001	.05	HP-58	25	.005	< .001	.002	.10
HP-39	26	.003	< .001	.001	.10						
Summary	335	0.008	0.001	0.002	0.10		206	0.006	<0.001	0.001	0.05

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.
[b] Sampling frequency—5 days per week.

Table 3. Radionuclides in raw milk, Oak Ridge Area January–June 1969

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131:			
Immediate environs	25	<10	<10
Remote environs	<10	<10	<10
Strontium-90:			
Immediate environs	47	7	21
Remote environs	22	10	17

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 3.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river. Samples are analyzed for the long-lived beta-particle emitters, uranium, and the transuranic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from January through June 1969.

Table 4. Concentrations of major radionuclides in the Clinch River, January–June 1969

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River[a]		
	Mile: 23.1 (Upstream)	Mile: 20.8[b] (Outfall)	Mile: 4.5 (Downstream)
Strontium-90	0.4	1.1	1.4
Cerium-144	.5	<.1	.4
Cesium-137	.8	.6	2.6
Ruthenium-106	1.2	.7	1.3
Cobalt-60	6.2	.5	6.3
Zirconium-niobium-95	.5	.1	.3
Gross beta	9.6	6.5	12.0

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 1).

[b] The concentrations at mile: 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For these samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 20 nCi/liter.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) was 0.16 percent of the AEC radiation protection standard for uncontrolled areas.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.05 percent, respectively, of the AEC radiation protection standard for natural uranium for uncontrolled areas.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.02 pCi/m^3. This is approximately 0.02 percent of the AEC radiation standard for uncontrolled areas.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were both less than 10 pCi/liter. These levels fall within the limits of FRC Range I

Table 5. External gamma radiation levels, Oak Ridge Area January–June 1969

Location	Radiation level (mR/h)						
	January	February	March	April	May	June	Average
Solway Gate	0.018	0.011	0.014	0.012	0.010	NA	0.013
Y-12, East Portal	.11	.10	.014	.012	.020	NA	.013
Newcomb Road	.013	.011	.016	.011	0.15	NA	.011
Gallaher Gate	.014	.013	.015	.013	.015	NA	.014
White Wing Gate	.012	.010	.018	.013	.012	NA	.013

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/h.
NA, no analysis.

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if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in the immediate and remote environs of the controlled areas were 21 pCi/liter and 17 pCi/liter, respectively. The average for the immediate environs, 21 pCi/liter, falls near the lower limit of FRC Range II and the value for the remote environs, 17 pCi/liter, falls within the limits of FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	June 1969
July–December 1968	January 1970

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2. Savannah River Plant[3]
January–June 1969

E. I. duPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont Environmental Monitoring Group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about a 25-mile radius from the center of the plant (figure 3). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected

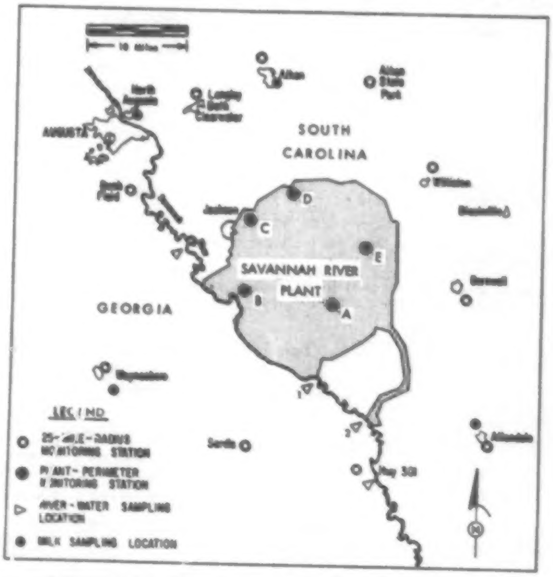

Figure 3. Environmental sampling locations Savannah River Plant

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[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1969" (DPST 69-30-2).

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regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S. C., are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background radioactivity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

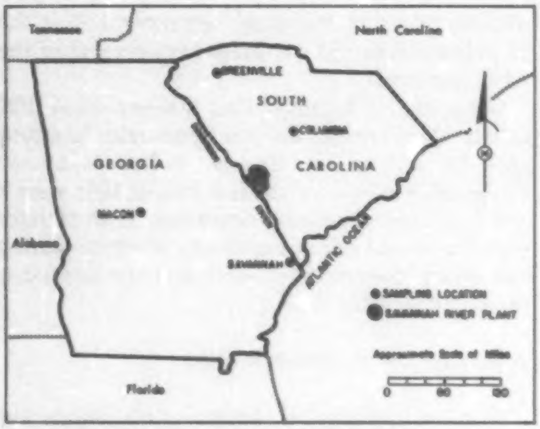

Figure 4. Distant air monitoring stations Savannah River Plant

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 6.5 pCi/liter and 12 pCi/liter, respectively. These values are 0.49 percent and 0.52 percent of the weighted average AEC radiation protection standards. The higher than normal average concentration reported for radioactivity at mile 23.1, Melton Hill Dam, was due primarily to cobalt-60. This contamination was found in the river upstream from the ORNL waste outfall and was the result of a source of contamination from a nuclear company upstream from Oak Ridge Operations. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.011 pCi/liter which is 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.013 mR/h, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

A release of airborne ruthenium-103 and plutonium-238 during a 2-week period in April from a separations area, near the center of the plant, was evident at air monitoring stations near the plant perimeter. Ruthenium-103 concentration in air averaged 0.16 pCi/m^3 at the 25-mile radius stations (March 28–April 10), the maximum concentration was 0.21 pCi/m^3 at Langley. Ruthenium-103 at the plant perimeter averaged 0.22 pCi/m^3 (March 28–April 14). The AEC standard for ruthenium-103 in air for the general population is 3,000 pCi/m^3. Although plant-released plutonium-238 could not be detected and identified beyond the manufacturing areas by gross alpha counting of routine air filters, chemical separation of the alpha-particle emitters on the filter papers, followed by low-level counting and spectrometry, showed that plutonium-238 was detectable at the plant boundary by special techniques. The plutonium-238 percentage of the total plutonium radioactivity was slightly higher than that previously measured in surface air samples exposed only to fallout. The plutonium-238 was not detectable on the sample filters at 25 and 100 miles from the plant even by the special separation and counting procedures.

Curium-244 levels showed an increase for a brief period in June at one monitoring station near the plant boundary (location C, figure 3). Alpha radioactivity in air at the monitoring station near Jackson was 0.006 pCi/m^3 for June 5 through June 13, compared to 0.0007 pCi/m^3 for May 20–June 5. The AEC radiation protection standard for the general population is 0.3 pCi/m^3. Increased deposition of alpha radioactivity also was measured at the location C monitoring station during June (0.19 nCi/m^2 as compared to about 0.008 at other locations). Release of more than the usual amount of curium-244 during a 10-minute period from a hot cell facility of the Savannah River Laboratory, combined with a northeasterly wind and a heavy rain, caused this localized condition.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fult separation areas, was obscured by fallout excepe during the April releases of ruthenium-103. The influence of nuclear tests, which resumed in September 1961, is shown in figure 5. The present low levels of atmospheric activity are attributed to

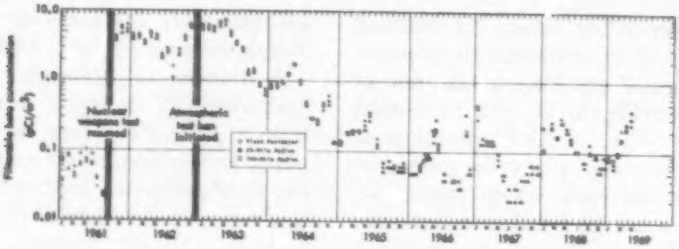

Figure 5. Influence of weapons tests

the moratorium on above-ground nuclear tests, which began in 1962. The observed spring increases are anticipated and result primarily from the mixing of the stratospheric debris into the troposphere. The average beta concentration in air increased from 0.09 to 0.16 pCi/m³ during the first half of 1969. Gamma-emitting radionuclides in fallout were cesium-134–137, cerium-141–144, ruthenium-103–106, and zirconium-niobium-95.

Radioactivity in air, determined from filter analyses, is shown in table 6. The January–June 1969 concentrations of filterable beta radioactivity (0.16 pCi/m³) and alpha radioactivity (0.0008 pCi/m³) in air were 0.16 and 1.1 percent of the respective AEC standards. Tritium oxide concentrations in air at the plant perimeter and at the 25-mile stations did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during January–June 1969 totaled 22 nCi/m² at the plant perimeter locations and 21 nCi/m² at 25-mile radius locations; comparable values for the last half of 1968 were 7 and 5 nCi/m². Increased deposition of zirconium-niobium-95 and strontium-89 was observed during this period. Deposition at each sampling location is presented in table 7.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous

Table 6. Radioactivity in air, Savannah River Plant, January–June 1969

Sampling points	Alpha radioactivity[a] (fCi/m³)			Nonvolatile beta radioactivity[b] (pCi/m³)			Specific radionuclides in composite samples (pCi/m³)					
	Maximum	Minimum	Average	Maximum	Minimum	Average	^{89,90}Sr	^{137}Cs	^{141,144}Ce	^{103,106}Ru	^{95}Zr-Nb	^{7}Be
Plant perimeter:												
A	1.6	0.5	0.8	0.30	0.06	0.15	0.007	0.01	0.05	0.05	0.08	0.32
B	1.2	.3	.8	.33	.06	.16						
C	1.8	.4	1.0	.27	.06	.14						
D	1.4	ND	.8	.28	.06	.18						
E	1.1	.4	.6	.28	.06	.15						
Average			0.8			0.16						
25-mile-radius:												
Aiken Airport	1.3	0.4	0.7	0.30	0.06	0.14	.007	.007	.04	.05	.07	.26
Aiken State Park	.9	.4	.6	.30	.06	.14						
Allendale	1.0	.4	.7	.32	.07	.15						
Barnwell	1.2	.3	.7	.30	.05	.14						
Bush Field	1.1	.3	.6	.28	.06	.13						
Langley	1.0	.4	.7	.34	.06	.16						
Sardis	.9	.3	.6	.33	.06	.15						
Waynesboro	1.3	.4	.7	.31	.06	.15						
Williston	1.4	.3	.7	.34	.06	.16						
Highway 301	1.3	.3	.6	.32	.01	.14						
Average			0.7			0.15						
Distant air-monitoring:												
S.C.												
Columbia	2.8	ND	1.1	0.44	0.01	0.16	.007	.007	.04	.04	.08	.21
Greenville	2.3	ND	1.0	.46	.05	.16						
Ga.												
Macon	1.2	ND	.7	48	.02	.17						
Savannah	1.7	ND	.9	31	.05	.17						
Average			0.9			0.16						

[a] AEC radiation protection standard—70 fCi/m³; sensitivity of analysis—0.3 fCi/m³.

[b] AEC radiation protection standard—100 pCi/m³; sensitivity of analysis—0.006 pCi/m³.

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Table 7. Total fallout deposited, Savannah River Plant, January–June 1969

Sampling points	Alpha (pCi/m^2)	Radioactivity concentrations (nCi/m^2)						
		Strontium–89	Strontium–90	Cesium–137	Cerium–141, –144	Zirconium–niobium–95	Beryllium–7	Ruthenium–103, –106
Plant perimeter:								
A	26	3.1	0.5	1.0	4.3	6.3	23.2	0.9
B	23	3.4	.6	1.2	6.0	5.8	26.8	1.1
C	192	3.2	.7	1.2	6.5	8.4	26.0	3.0
D	44	4.0	.7	1.5	8.8	10.0	41.6	4.1
E	35	3.2	.6	1.4	7.1	8.0	41.1	2.5
Average	64	3.6	.6	1.3	6.6	7.7	31.8	2.4
25-mile-radius:								
Aiken Airport	19	2.7	.8	1.1	6.8	7.5	25.4	2.6
Aiken State Park	26	2.4	.6	1.6	6.9	9.6	30.1	2.0
Allendale	29	2.0	.5	.7	3.9	3.2	19.1	.7
Barnwell	10	1.7	.5	.8	4.9	6.3	23.7	1.5
Bush Field	22	1.8	.7	1.7	8.5	11.9	34.5	2.0
Langley	50	4.4	.9	1.9	10.1	13.4	46.5	4.4
Sardis	20	2.0	.5	1.4	7.0	10.0	29.6	2.5
Waynesboro	50	2.8	.8	1.4	6.0	6.8	35.7	2.0
Williston	20	2.3	.6	.8	3.7	3.4	13.8	
Highway 301	44	2.2	.6	1.3	10.2	10.6	33.5	1.7
Average	29	2.4	.7	1.3	6.8	8.3	29.2	2.0

algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to, and downstream from the Savannah River Plant effluents. Determination of radionuclides in algae is important because algae concentrate most radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station upstream from SRP effluents, the increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium-141, -144, chromium-51, zirconium-niobium-95, manganese-54, zinc-65, and cobalt-60 were detected less frequently. Radiostrontium (maximum, 24 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 7 pCi/g, wet weight) was detected in the flesh tissue. The maximum concentrations of phosphorus-32 detected in bone of river fish was 13 pCi/g; and the maximum phosphorus-32 in flesh of river fish was 27 pCi/g.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 6). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged <4 nCi/liter (0.1 percent of the AEC standard) during the January–June 1969 period. The annual radiation exposure of an individual in this population due to

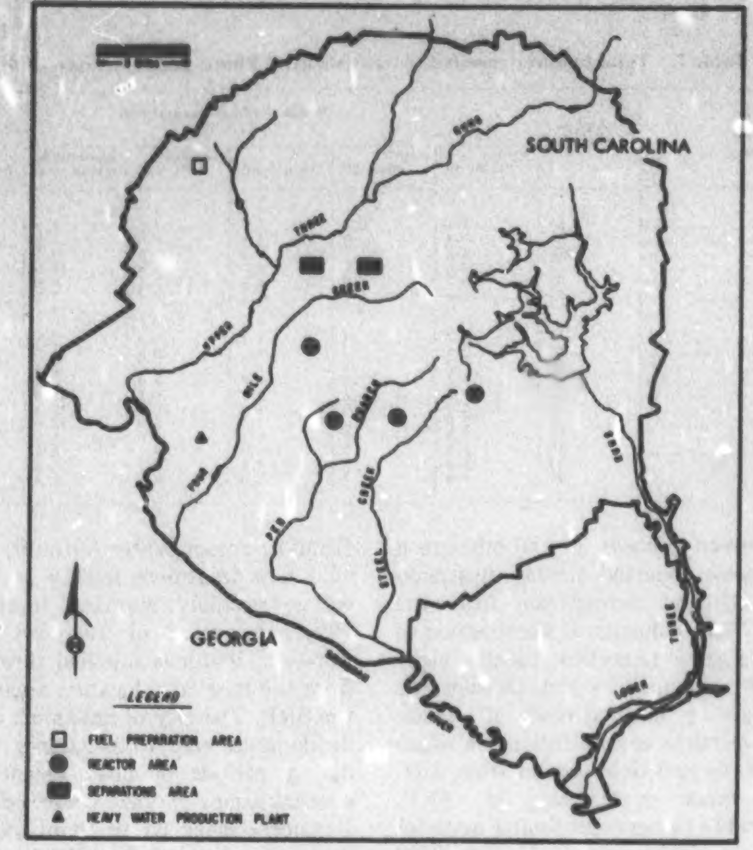
Table 8. Radioactivity in public water supplies January–June 1969

Sampling points	Alpha radioactivity[a] (pCi/liter)	Nonvolatile beta radioactivity[b] (pCi/liter)
	April	April
Aiken	2.2	7
Allendale	.2	ND
Augusta	ND	ND
Barnwell	ND	4
Bath	2.2	8
Blackville	.4	ND
Clearwater	.2	4
Jackson	2.8	7
Langley	1.2	ND
New Ellenton	1.4	ND
North Augusta	2.5	6
Sardis	<.2	ND
Waynesboro	<.2	6
Williston	1.1	5
Average	1.1	5

[a] AEC radiation protection standard —10 pCi/liter, sensitivity of analysis—0.2 pCi/liter.

[b] AEC radiation protection standard—3 nCi/liter, sensitivity of analysis—4.0 pCi/liter.

ND, nondetectable.


SOUTH CAROLINA
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PEN
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RUNS
THREE
LOWER
SAVANNAH
RIVER
LEGEND
FUEL PREPARATION AREA
REACTOR AREA
SEPARATIONS AREA
HEAVY WATER PRODUCTION PLANT

Figure 6. SRP production and effluent streams

the consumption of water containing this concentration of tritium is <0.7 mrem. This exposure may be compared with 40 mrem/a from natural potassium found in the human body or with the 170 mrem/a specified by the Federal Radiation Council as the annual dose guide for members of the public.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.1 pCi/liter) and beta radioactivity (5 pCi/liter) were essentially the same as those observed before plant startup. Radioactivity in public water supplies data are presented in table 8.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Concentrations of alpha and nonvolatile beta particle radioactivity in river water for the past year are presented in table 9. Average concentrations of specific radionuclides found in river water during January–June 1969 appear in table 10.

Tritium, sulfur-35, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from the Savannah plant.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water

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Table 9. Radioactivity in Savannah River water, July-December 1968 and January-June 1969

Sampling points	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	January–June 1969			July–December 1968	January–June 1969			July–December 1968
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.6	ND	<0.2	<0.2	7	<4	<4	<4.0
Downstream from Steel Creek	.3	ND	< .2	< .2	11	<4	4	5
Downstream from Lower Three Runs Creek	.5	ND	< .2	< .2	17	<4	7	11
3 miles downstream from Lower Three Runs Creek	.7	ND	< .2	< .2	13	<4	5	6

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, nondetectable.

Table 10. Average concentration of radionuclides in Savannah River water January—June 1969

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent AEC standard at Highway 301
Tritium	600	880	6,600	0.20
Ruthenium-103, 106	3.2	ND	ND	<.03
Cerium-141, 144	2.5	ND	ND	<.03
Cesium-134, 137	.6	ND	.5	.002
Neptunium-239	2.2	ND	ND	<.003
Barium-lanthanum-140	1.6	ND	ND	<.01
Zirconium-niobium-95	.5	ND	ND	<.001
Chromium-51	4.3	ND	ND	<.001
Strontium-89	.3	ND	.4	.01
Iodine-131	.5	ND	ND	<.16
Strontium-90	.01	.6	1.0	.33
Cobalt-60	1.4	ND	ND	<.005
Zinc-65	1.1	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Sulfur-35	5.0	ND	3.8	.006

ND, nondetectable, less than sensitivity of analysis.

moderator in the reactors. Chromium-51 and sulfur-35 (also a beta-particle emitter), the second and third most abundant radionuclides released to the river, are produced by neutron irradiation of stable chromium and stable sulfur. Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The tritium, chromium-51 and sulphur-35 concentrations in river water averaged 0.20, <0.001 and 0.006 percent of the AEC radiation protection standards, respectively.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or sorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route (these are not designated on figure 2). Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year. Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.1 pCi/g during the last half of 1968; gamma-ray emitters averaged 17.6 and 22.4 pCi/g, respectively, as compared to 7.4 and 8.6 pCi/g for the last half of 1968. Radioactivity in grass samples is presented in table 11.

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Table 11. Radioactivity on vegetation January–June 1969

Radionuclides[a]	Concentration (pCi/g dry weight)			
	Plant perimeter (7 locations)		25-mile radius (7 locations)	
	Maximum	Average	Maximum	Average
Alpha emitters	0.7	0.2	0.6	0.2
Cesium-137	1.2	.8	1.0	.8
Cerium-141, -144	9.4	5.7	10.5	7.1
Ruthenium-103, -106	<1.4	<1.4	1.8	.3
Beryllium-7	14.8	9.8	17.9	12.3
Iodine-131	< .2	< .2	< .2	< .2
Barium-lanthanum-140	<6	<6	<6	<6
Zirconium-niobium-95	2.4	1.3	3.7	1.9

[a] Sensitivity of analysis in pCi/g dry weight; alpha emitters, 0.10; cesium-137, 0.3; cerium-141, -144, 1.0; ruthenium-103, -106, 1.4; beryllium-7 3.0; iodine-131, 0.2; barium-lanthanium-140, 6.0; zirconium-niobium-95, 0.5.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant (figure 2). Samples, collected biweekly, were analyzed for tritium and radioiodine. Strontium-90 and cesium-137 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1969 are shown in table 12.

Average concentrations of the radionuclides in milk were 11 pCi/liter of strontium-90 (compared to 10 pCi/liter of strontium-90 during the last half of 1968) and 13 pCi/liter of cesium-137. Iodine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of a concentration less than 0.1 percent of the AEC standard for water.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1969 data (shown in table 13) are characteristic of measurements observed at individual stations for the past several years.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation or was obscured by fallout from offsite sources. Release of more than the usual amounts of ruthenium-103 in April and curium-244 for a brief period in June caused detection of these radionuclides in air at several points near the plant boundary. The temporary levels were below the respective AEC radiation protection standards. Beta radioactivity in air was about the same as that observed for January–June 1968 and was a twofold increase over the previous 6-month period. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed 0.3 percent of the AEC radiation protection standard.

Table 12. Radioactivity in milk from local dairies, Savannah River Plant January–June 1969

Distributing points	Tritium[a] (nCi/liter)			Strontium-90[b] (pCi/liter)		Cesium-137[c] (pCi/liter)	
	Maximum	Minimum	Average	March	June	March	June
Aiken	5	ND	ND	6	14	6	18
North Augusta	6	ND	ND	11	27	13	22
Waynesboro	11	ND	ND	4	NS	ND	NS
Major distributors[d]	4	ND	ND	5	10	12	16

[a] Sensitivity of analysis—3 nCi/liter. AEC standard—3,000 nCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter. AEC standard—300 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter. AEC standard—300 pCi/liter.
[d] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.
NS, no sample.

Table 13. Environmental gamma radiation, Savannah River Plant, January–June 1969

Sampling points	Gamma radiation (mR/day)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.70	0.12	0.40
B	.41	.18	.34
C	.44	.12	.25
D	.66	.11	.36
E	.42	.15	.22
Average			0.32
25-mile-radius:			
Aiken Airport	.77	.10	.31
Aiken State Park	.32	.13	.22
Allendale	.38	.21	.28
Barnwell	.72	.08	.25
Bush Field	.41	.13	.31
Langley	.59	.08	.27
Sardis	.49	.16	.32
Waynesboro	.74	.14	.29
Williston	.18	.08	.14
Highway 301	.40	.14	.28
Average			0.27

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	January 1969
July–December 1968	November 1969

Reported Nuclear Detonations, April 1970

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that it had conducted two nuclear tests during April 1970.

Both nuclear tests were conducted underground by the Atomic Energy Commission at its Nevada Test Site on April 21, 1970. One was in the low yield range of less than 20 kilotons TNT equivalent, the other in the intermediate yield range (between 20 to 200 kilotons TNT equivalent).

There was some release of gaseous radioactivity from the smaller test. A small amount of radioactivity was detected by the U.S. Public Health Service in the vicinity of Coyote Summit, an unpopulated area on Highway 25 about 10 miles from the boundaries of the government-controlled area.

It was detectable only on sensitive scientific instruments and presented no health hazard. The readings returned to normal background levels in about an hour.

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Errata

In the article "Environmental Survey of Uranium Mill Tailings Pile, Tuba City, Arizona" published in the November 1969 issue of *Radiological Health Data and Reports*, there appeared several errors in tables 6 and 8 on pages 484 and 485.

In table 8 on page 485 change the station 7-radon-222 average from 3.5 to 3.0 pCi/liter.

Table 6. Gross alpha to radium-226 ratios, long-lived airborne particulate activity, Tuba City uranium mill, May 1967

Sample number	Gross alpha (pCi/m³)	Radium-226 (pCi/m³)	Gross alpha/ radium-226
31	.15	.04	3.8
68	.69	.10	6.9
101	.18	.02	9.0
103	.23	.04	5.8

In the January 1970 issue of *Radiological Health Data and Reports*, an error occurred in table 3 of the milk surveillance article on page 17. The iodine-131 12-month average for Portland, Maine, should be 1, and for Baltimore, Md., it should be 0.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

CESIUM-137 CONCENTRATIONS IN ESKIMOS, SPRING 1968. *J. A. Eckert, J. S. Coogan, R. L. Mikkelsen,* and *P. N. Lem. Radiological Health Data Reports, Vol. 11, May 1970,* pp. 219–225.

To determine cesium-137 concentrations, 996 residents of 11 Alaskan villages were whole-body counted during April 1968. The methods of counting and selection of villages were chosen to complement the spring 1967 counts made by Rechen et al. The villages counted in this study were: Ambler, Anaktuvuk Pass Village, Egegik, Kiana, Mekoryuk, Noatak, Noorvik, Selawik, Shishmaref, Shungnak and Teller.

The maximum and average concentrations, considering all villages, were 24.27 nCi/kg and 4.37 nCi/kg, respectively. The average radiation dose index was 34.1 mrad/a. A comparison of the radiation dose indices of individuals counted both in the spring of 1967 and the spring of 1968, indicates that in two villages out of ten there was a significant decrease in the indices.

The inhabitants of villages living on a diet of caribou or moose meat had a higher cesium-137 burden than the inhabitants of villages where reindeer herds supply the main meat source.

The calibration formulas of Rechen and Palmer are compared and it is concluded that earlier studies made by Hanson and Palmer are compatible with the more recent studies made by the U.S. Public Health Service.

KEYWORDS: Alaska, body burdens, cesium-137, Eskimos, radiation dose index, spring 1968.

TRITIUM BODY BURDEN OF CHILDREN, 1967–1968. *A. A. Moghissi* and *Robert Lieberman. Radiological Health Data and Reports, Vol. 11, May 1970,* pp. 227–231.

The tritium concentration in body water of children was determined from samples of urine taken from two children in each of nine Institutional Total Diet Sampling Stations. The tritium concentrations in body water of children gradually decreased from about 1.5 nCi/liter to less than 0.2 nCi/liter during the period, January 1967 to December 1968. Several anomalies were noted.

The dose equivalent from tritium for standard man was calculated to be 0.15 mrem for 1967 and 0.13 mrem for 1968. The dose equivalent for children varies according to age and is roughly 0.1 mrem for a 13-year old child.

KEYWORDS: Body burdens, children, tritium, United States, urine.

TRITIUM CONCENTRATIONS IN FOOD, 1967–1968. *A. A. Moghissi* and *R. J. Lyon. Radiological Health Data and Reports, Vol. 11, May 1970,* pp. 233–236.

Tritium concentrations were determined in food samples obtained from several children's homes in the United States. The average concentrations of tritium in food indicate a decreasing trend from 1967 to 1968. The average dose equivalent from tritium in food was calculated to be 0.08 mrem for 1967 and 0.03 mrem for 1968.

KEYWORDS: Children's diets, food, tritium, United States.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 6, June 1970

In August 1969, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Technical Notes

Zirconium-95 in Utah Vegetation Produced During the 1966 Growing Season[1]

R. C. Pendleton and *R. D. Lloyd*[2]

An unexpectedly intense gamma-ray peak at about 0.76 MeV was observed in a number of vegetation samples collected throughout Utah during 1966. These samples had been counted in February 1967 for the determination of cesium-137 levels. The spectrometer used consisted of a 400-channel pulse-height analyzer receiving signals from a pair of 8-by 4-inch NaI (Tl) crystals housed in a 6-inch thick steel shield and operating in concert (*1*). Counting data were analyzed by using computer techniques (*2*). All samples had been stored in double plastic bags since collection and the outer bag was removed just before the sample was counted. A few samples were repackaged in new containers and were recounted. No diminution of their 0.76 MeV peaks was produced by this procedure. In many samples, the peak at about 0.76 MeV dominated the gamma-ray spectra (figures 1 and 2). Some of the samples had been collected more than 8 months prior to counting, nearly four half-lives of zirconium-95, which was suspected as being responsible for the peak. Since no highly contaminating nuclear event was known to have occurred locally in 1966 and no announced ventings occurred in our area after April 1966, it seemed unlikely that a large amount of 65-day half-life zirconium-95 would have been present in significant amounts.

Four representative samples were selected for serial counting in an attempt to determine the

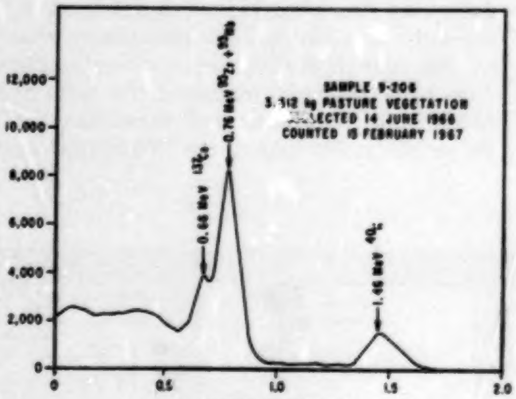

Figure 1. Photon spectrum of a typical vegetation

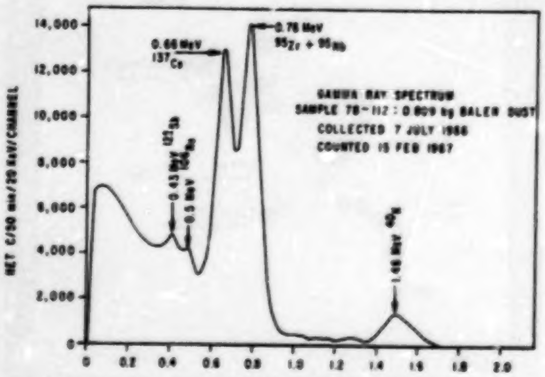

Figure 2. Photon spectrum of a baler dust sample

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[1] This investigation was supported by U.S. Public Health Service Research Grant RH-00030, Bureau of Radiological Health.

[2] University of Utah, Salt Lake City, Utah.

radioactive half-life of the unknown emitter. Serial counting of these samples from February to October 1967 yielded an average half-life of 68.4 ± 6.2 days in agreement with the 65-day value for zirconium-95, but very different from the tabulated half-lives of other suspect radionuclides exhibiting gamma-ray energies of about 0.76 MeV (*3*).

No evidence of zirconium-95 was found in environmental samples collected in 1965. Only very small amounts of the nuclide (80 to 660 pCi/kg) were found in samples collected in the fallout tract of the "Pinstripe" event in southern Utah during April 1966. Inspection of collection dates for the 1966 vegetation samples suggested that the contaminating event probably occurred between May 14 and June 13, 1966, since samples collected May 14 at station number 60 showed no detectable zirconium-95, but samples collected at the same location on June 29 averaged about 14 nCi/kg, and those obtained at other locations on June 13 or later also contained this radionuclide. Much of this contaminated vegetation had not yet grown at the time of the "Pinstripe" venting and was collected far from the area of the fallout track. Maps of the location of origin for each contaminated sample showed that zirconium-95 had been widespread throughout the State of Utah (figure 3).

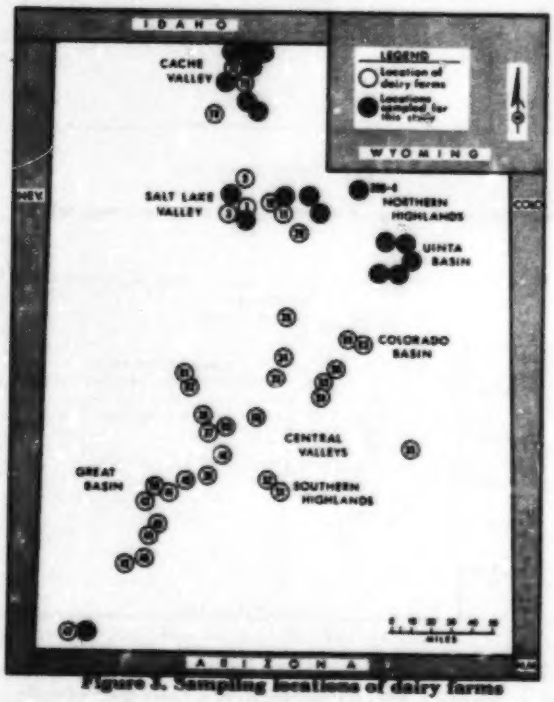

Figure 3. Sampling locations of dairy farms

Table 1 lists the announced nuclear detonations during May and June 1966 (*4-5*). The Chinese device was detonated in the atmosphere and the United States tests were all underground. None of these underground explosions were reported to have vented.

Table 1. Announced nuclear detonations in May and June 1966

Date	Location	Yield (kilotons)
May 4	Nevada Test Site	<20
May 5	Nevada Test Site	<20
May 6	Nevada Test Site	20-200
May 9	China	200-1,000
May 12	Nevada Test Site	<20
May 13	Nevada Test Site	20-200
May 19	Nevada Test Site	20-200
May 27	Nevada Test Site	<20
June 2	Nevada Test Site	20-200
June [illegible]	Nevada Test Site	20-200
June 10	Nevada Test Site	<20
June 25	Nevada Test Site	<20
June 30	Nevada Test Site	200-1,000

Measurements made by the Utah State Department of Health (*3*) of gross beta radioactivity in air for Utah sampling stations for May and June 1966 did not reveal elevated air concentrations of radioactivity during the period May 14 to June 13 (table 2)[3]. Data from 19 sampling stations showed that radioactivity was detected in Utah air during the period, May 14 to June 13, but this was also true of March and early April when, presumably, no contaminating events occurred. For only 6 of the 19 Utah stations was the May maximum the highest of this 4-month period, and for 3 of the stations the May maximum was the lowest. Only a single station (Moab) exhibited a maximum which was significantly higher than the monthly average in mid-May when fallout from the third Chinese test was reported to have reached the Intermountain area. (*7*). Nine stations showed a maximum during the final 9 days of the month, but only 2 of these values (Parowan, Monticello) were much higher than typical maxima for the State during March. The exact date of

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[3] Data in table 2 illustrate the clear-cut way in which the relatively small amount of fallout from the "Pinstripe" event was detected by this sampling network during the last week in April 1966. Utah stations in the fallout track were Cedar, Garrison, Monticello, Price, Provo, and Richfield. However, entry of the much more intense fallout from the May 9 Chinese test can not be similarly seen in the data for May.

Table 2. Dates and concentration of maximum measured gross beta radioactivity in the air at 19 Utah locations during March–June 1966

Station	March		April		May		June	
	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)
Bryce (PHS)[b]	15	2.6	6, 25	2.6	15	1.5	30	2.3
Cedar (PHS)	26	2.0	25	2.4	29	3.4	4	3.5
Delta (PHS)	26	3.3	6	4.9	1	2.7	16	1.7
Dugway (PHS)	24	3.0	1	1.2	22	1.3	—	0
Garrison (PHS)	—	—	26	7.8	3	9.3	18	9.5
Logan	25	2.1	6	2.1	4, 9, 15, 31	2.1	27, 29, 30	2.1
Logan (PHS)	31	3.4	7	4.7	4	3.6	30	4.4
Moab	6	2.9	9	2.9	15	13.8	10	3.0
Monticello (PHS)	6	2.4	25	3.9	21	8.5	14, 18	3.9
Ogden	24	1.0	5, 14, 25	1.3	22	1.6	15, 20, 26	1.0
Parowan (PHS)	—	0	—	0	20	6.4	8	1.0
Price	12, 18, 24, 25	0.9	26	1.2	3, 12, 21	1.0	7	1.4
Provo (PHS)	31	2.8	26	10.3	2	2.7	1, 2	0.9
Richfield	28	3.2	26	16.2	25	2.6	11	2.2
Roosevelt (PHS)	26	8.7	6	6.7	9	4.9	29	4.9
Salt Lake (PHS)	6, 24, 25, 31	1.7	8	2.7	22	2.8	28	2.9
Salt Lake (RSN)[c]	10	2.7	9	1.8	22	6.2	1	1.7
St. George	17, 25	1.8	20	1.4	31	1.8	5, 6	1.4
Wendover (PHS)	25	3.6	14, 16, 21	3.2	14	3.1	23	7.5

[a] Source of data: Utah State Department of Health Document SDH-San-109-10/66, October 1966 (field estimates).
[b] Stations marked "PHS" were operated cooperatively with the U.S. Public Health Service.
[c] PHS Radiation Surveillance Network station.

this contaminating event cannot be deduced from these data. Therefore, the concentration of zirconium-95 in each vegetation sample was corrected for radioactive decay to June 1, 1966, for purposes of comparison (table 3 and figure 3).

Data supplied by the Southwestern Radiological Health Laboratory (SWRHL)[4] indicate that calculations of air beta-concentrations, based on their evaluation of these same filters at varying times after removal from the air samplers, are in serious disagreement with values reported in reference 6. Their estimates of air beta concentrations are higher in some cases and lower in others. In general the SWRHL data suggest a very long-term but chorologically varying exposure of the Utah air sampling network to freshly-produced fallout from mid-May to mid-June 1966. This is in agreement with the expectation that the May 9 test on the Chinese mainland was responsible for at least part of the radioactivity detected.

Several vegetation samples had been collected in southern Utah on April 30, 1966, following the April 25, 1966, venting of an underground nuclear detonation at the Nevada Test Site (*9*). Small quantities of the short-lived fission products, iodine-131, ruthenium-103, and zirconium-95, were detected in these 5 samples when counted on May 3, 1966. Dairy cattle in Utah were generally not grazing on open pastures at the time of the April 25, 1966 venting. The absence of significant amounts of iodine-131 in milk was confirmed by gamma-ray analysis of milk from several Salt Lake dairies and milk farms which showed iodine-131 in vegetation samples, However, cattle were on pasture by June, and the deposition of fresh fission products on vegetation during this time should have indicated by sharply rising iodine-131 levels in milk. The U.S. Public Health Service Pasturized Milk Network data for May and June 1966 showed only tiny increases in Utah milk (to 20 pCi/liter only and not until June 7 and 17) (*9-10*). Although the concentration of zirconium-95 in 1966 forage vegetation (table 3) was similar to that in samples collected following the Nevada tests of July 1962, iodine-131 milk levels were much higher in 1962 (up to 62,500 pCi/liter for milk contributed

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[4] Melvin W. Carter, Southwestern Radiological Health Laboratory, personal communication.

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to the Salt Lake milk pool) (see equation 3 and table 1, farm #60, in reference 12). During the 1962 incident, vegetation and milk were collected from a number of Utah dairy farms (*11*, figure 3). In two cases, vegetation and milk had been obtained from a farm at about the same time. For one, the vegetation contained about 24,000 pCi/kg of zirconium-95 and the milk had about 5,000 pCi/liter of iodine-131; for the other, the vegetation contained about 17,000 pCi/kg zirconium-95 and the milk had about 3,000 pCi/liter of iodine-131. The average ratio of iodine (pCi/liter of milk) to zirconium (pCi/kg of vegetation) in these 2 cases was about 0.2. Under similar conditions, 1966 milk may have had up to 7,120 pCi/liter of iodine-131 (table 3, farm #78). The 1962 "Sedan" event was a cratering shot, followed by "Small Boy" which was detonated at the earth's surface. It is conceivable that the fallout from a partially contained cratering event might have been enriched in the iodine isotopes relative to zirconium-95. Even if the difference in type of shot, particle size and delay of fallout arrival reduced the iodine-131 to zirconium-95 ratio by a factor of 9 to 36, milk obtained in 1966 might have been expected to have contained 200 to 800 pCi of iodine-131 per liter. Carter[4] estimated the reduction in the iodine-131 to zirconium-95 ratio in the fallout from the Chinese test conducted on May 9 compared with Sedan-Small Boy as a factor of 6 to 24 or more.

Levels of radioactive materials in the baler dust (figure 2, table 3) may be of possible significance because, in addition to the initial exposure of farm workers who may be in the open when a fallout cloud passes through, the farmer is exposed to subsequent secondary aerosols generated during harvesting or processing of crops which can have a relatively high concentration of radioactivity. Some samples of baler dust taken in 1966 contained near microcurie quantities of gamma-ray emitting nuclides per kg[5].

Summary

Levels of zirconium-95 in crops and dust from farm implements indicated widespread contamination of Utah with fresh fission products during May or June 1966. Although the exact origin and date of arrival of the zirconium-95 in these vegetation samples cannot be determined from available evidence, at least part was probably from the atmospheric nuclear detonation on the Chinese mainland. No important increase of iodine-131, cesium-137, or strontium-90 has been reported for these months, but there is evidence that farm workers could have been exposed to secondary aerosols containing relatively high levels of radioactivity. This indicates that a potential radiological hazard may have occurred in past highly contaminating incidents and may recur, if a highly contaminating incident takes place in the future.

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(*11*) PENDLETON, R. C., C. W. MAYS, R. D. LLOYD, and A. L. BROOKS. Differential accumulation of iodine-131 from local fallout in people and milk. Health Physics 9:1253–1262 (1963).

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[5] For example, as of the date of collection, sample 4–206 contained per kg about 3,500 pCi antimony–125, 2,300 pCi ruthenium–106, 4,200 pCi cesium–137 and 190,000 pCi zirconium–95 plus about 410,000 pCi niobium–95. The total of these longer-lived, high-energy gamme-ray emitters is about 0.6 μCi. There was undoubtedly present, soon after deposition, many short-lived nuclides such as the iodine isotopes, ruthenium–103, barium–140, etc. The beta emitters; tritium, strontium–89, strontium–90, etc., were probably present but were not measured. In addition there may have also been quantities of plutonium–239 and other alpha-particle emitters.

Table 3. Zirconium-95 in 1966 Utah vegetation collected after May 13

Station	Sample	Collection date (1966)	Sample type	Zirconium-95 (nCi/kg net weight) (corrected to 6/1/66)
2	203	6/13	pasture vegetation	9.7
	204		alfalfa	28.8
	205		baler dust[a]	105.3
	215	7/20	alfalfa	1.6
	216		pasture vegetation	2.7
	225	9/14	alfalfa	1.3
	226		grass hay	8.4
	229	9/18	pasture vegetation	1.3
4	204	6/13	pasture vegetation	5.1
	205		alfalfa	21.1
	206		baler dust	211.2
	226	11/16	barley	0
	229	12/14	alfalfa	2.4
	230		alfalfa	2.1
9	206	6/14	pasture vegetation	19.0
	220	9/16	alfalfa 1st crop	16.4
	221		alfalfa 2d crop	1.9
	222		grass hay	5.1
	225		pasture vegetation	17.6
21	203	6/14	pasture vegetation	4.6
	219	9/29	alfalfa	9.5
22	207	6/15	pasture vegetation	19.3
	210		pasture vegetation	12.0
	228	9/16	pasture vegetation	6.8
	229		alfalfa	.8
	230		alfalfa	1.0
	231		alfalfa	1.1
48	119	6/28	baler dust	76.6
57	141	6/28	alfalfa	26.6
	147	8/5	green chop[b]	1.4
	153	9/20	green chop	.6
58	145	6/28	alfalfa	23.2
	152	8/10	baler dust	10.4
	153		alfalfa	2.4
	159	10/1	alfalfa	.8
59	145	6/29	pasture vegetation	9.2
	152	8/10	pasture vegetation	3.2
	157	9/20	pasture vegetation	1.5
60	150	5/14	alfalfa	0
	154		pasture vegetation	0
	159	6/29	pasture vegetation	16.1
	162		pasture vegetation	10.8
	165		pasture vegetation	13.8
	174	8/5	baler dust	46.9
	185	9/20	pasture vegetation	5.4
	186		pasture vegetation	1.2
	190	10/1	alfalfa	1.6
68	118	6/29	pasture vegetation	8.6
	119		alfalfa	14.1
	120		baler dust	43.1
	131	10/1	alfalfa	1.1
	133	11/3	silage	0
70	200	7/5	alfalfa	14.9
	213	9/15	baler dust	50.6
	216	10/25	alfalfa	1.5
	217		alfalfa	1.6
71	162	7/7	alfalfa	17.4
	163		grass hay	.8
	168	9/15	green chop	0
	169		alfalfa 2d crop	1.8
74	209	7/7	alfalfa	25.5
	210		pasture vegetation	4.9
	225	10/25	alfalfa	11.6
75	158	7/7	alfalfa	17.4
	159		grass hay	1.1
	164	9/15	green chop	.4
	167	9/19	alfalfa	2.0
	172	10/25	silage	0
76	210	7/6	pasture vegetation	5.7
	211		alfalfa	9.1
	214	7/11	baler dust	45.8
	227	9/19	pasture vegetation	1.9
	228		alfalfa	1.1
	236	11/26	alfalfa	1.7
77	152	7/6	pasture vegetation	8.1
	153		alfalfa	13.3
	154		baler dust	98.6
	165	9/15	alfalfa	3.9
	166		alfalfa	1.0
	169		pasture vegetation	2.4
	179	11/26	silage	0
78	110	7/5	pasture vegetation	5.0
	111		alfalfa	35.6
	112		baler dust	142.9
	113		native vegetation	23.1
	135	11/26	alfalfa	1.1
	136		alfalfa	1.7
205–4	88	8/26	native vegetation	34.8

[a] Dust collected from surfaces of farm equipment used in harvesting crops—for convenience called baler dust.
[b] Alfalfa cut and fed without drying.

SECTION I. MILK AND FOOD

Milk Surveillance, February 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and

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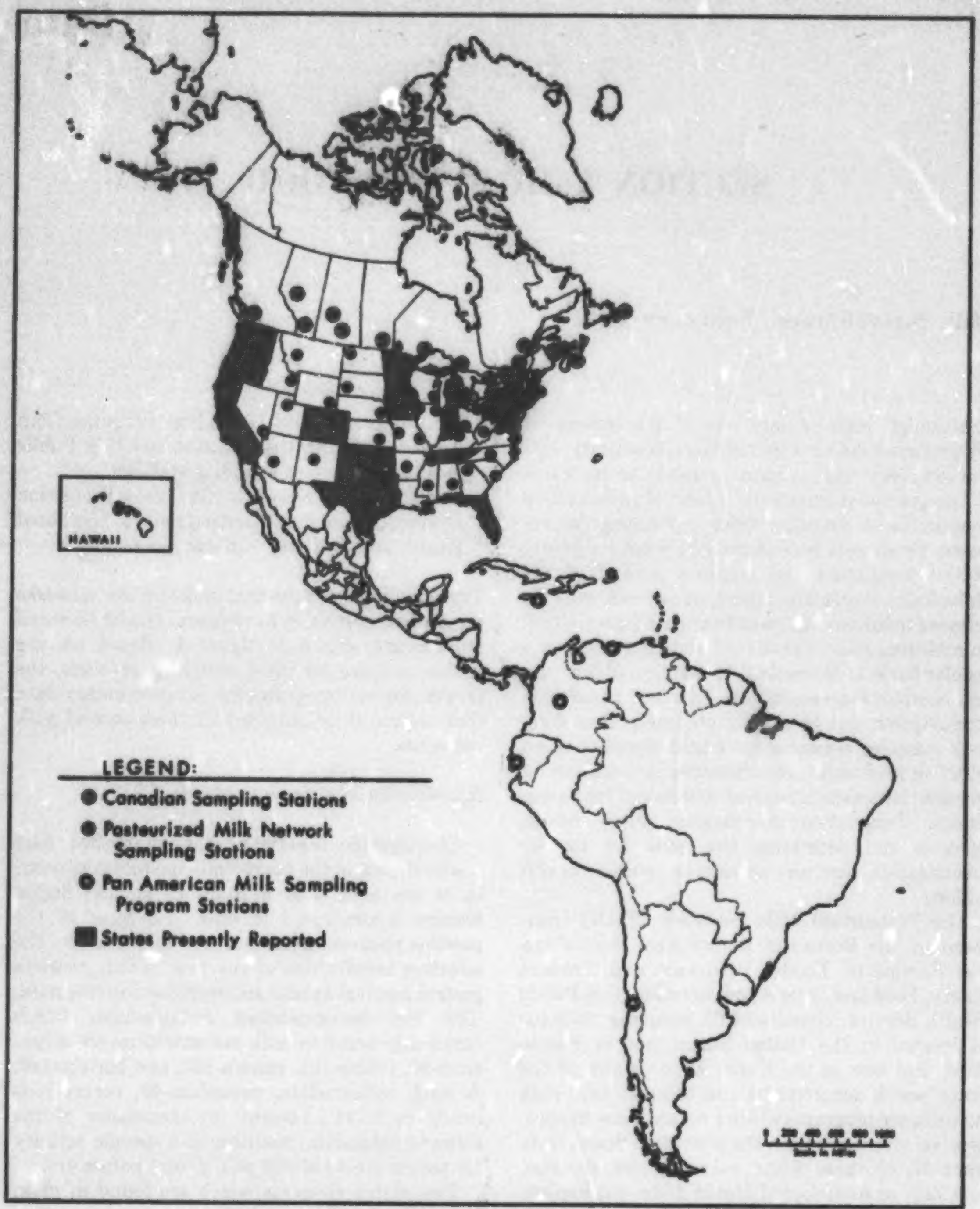
HAWAII
LEGEND:
● Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Milk Sampling Program Stations
■ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations (2σ), for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 14 participated in the experiment.

The iodine-131 and cesium-137 results show much improvement over previous tests. Barium-140 results also look good, which is encouraging, since this is the first time barium-140 was analyzed for this type of experiment. However, strontium-89 and strontium-90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

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was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89 Strontium-90 Cesium-137	Bone marrow Bone marrow Whole body	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000 [c]81,000 [c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

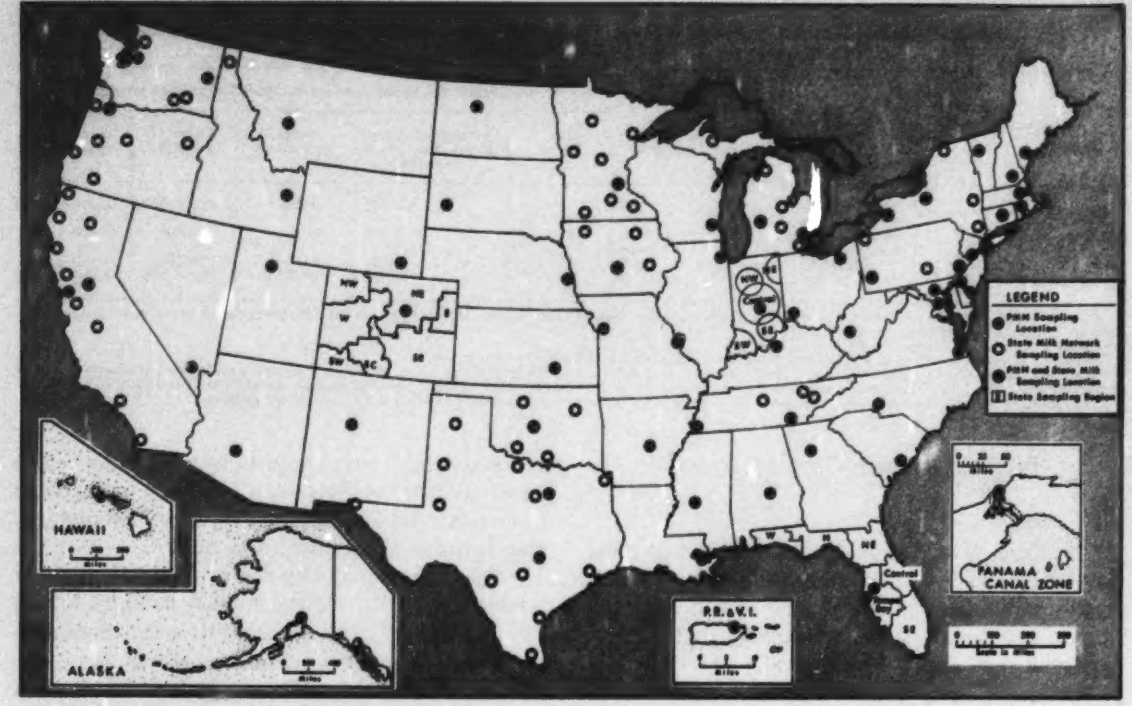

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for February 1970 and the 12-month period, March 1969 to February 1970. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for February

Table 3. Concentration of radionuclides in milk for February 1970 and the 12-month period, March 1969 through February 1970

Sampling location		Type of sample	Strontium-90 Monthly average	Strontium-90 12-month average	Iodine-131 Monthly average	Iodine-131 12-month average	Cesium-137 Monthly average	Cesium-137 12-month average
			Radionuclide concentration (pCi/liter)					
UNITED STATES:								
Ala:	Montgomery	P	5	6	0 (4)	0	4 (4)	9
Alaska:	Palmer	P	3	6	0 (4)	0	3 (4)	6
Ariz:	Phoenix	P	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock	P	10	16	0 (4)	0	10 (4)	13
Calif:	Sacramento	P	2	1	0 (3)	0	0 (3)	0
	San Francisco	P	0	1	0 (4)	0	0 (4)	0
	Del Norte	P	14	19	0	0	19	20
	Fresno	P	3	2	0	0	2	3
	Humboldt	P	4	5	0	0	5	7
	Los Angeles	P	2	2	0	0	2	3
	Mendocino	P	3	4	0	0	6	5
	Sacramento	P	2	2	0	0	7	5
	San Diego	P	3	2	0	0	1	3
	Santa Clara	P	2	2	0	0	7	4
	Shasta	P	4	3	0	0	4	5
	Sonoma	P	1	2	0	0	5	4
Colo:	Denver	P	5	5	0 (4)	0	0 (4)	1
	West	R	(5)		NS	(5)	NS	(5)
	Northeast	R	(5)		(5) (4)	(5)	(5)	(5)
	East	R	(5)		(5)	(5)	(5)	(5)
	Southeast	R	(5)		NS	(5)	NS	(5)
	South central	R	(5)		NS	(5)	NS	(5)
	Southwest	R	(5)		(5)	(5)	(5)	(5)
	Northwest	R	(5)		NS	(5)	NS	(5)
Conn:	Hartford	P	6	6	0 (4)	0	8	10
	Central	P	7	7	0 (4)	0	11 (5)	11
Del:	Wilmington	P	7	8	0 (4)	0	3 (4)	5
D.C:	Washington	P	7	7	0 (4)	0	11 (4)	4
Fla:	Tampa	P	8	6	0 (4)	0	45 (4)	26
	West	R	13	13	0	0	22	28
	North	R	17	14	0	0	28	30
	Northeast	R	6	7	0	0	26	35
	Central	R	6	8	0	0	17	30
	Tampa Bay area	R	6	8	0	0	42	34
	Southeast	R	NA	8	0	0	52	34
Ga:	Atlanta	P	7	9	0 (4)	0	16 (4)	10
Hawaii:	Honolulu	P	1 (8)	2	0 (4)	0	0 (4)	0
Idaho:	Idaho Falls	P	6	5	0 (4)	0	4 (4)	6
Ill:	Chicago	P	6	7	0 (4)	0	12 (4)	9
Ind:	Indianapolis	P	8	8	0 (4)	0	8 (4)	4
	Northeast	P	9	10	0	1	11	11
	Southeast	P	10	8	0	0	20	11
	Central	P	8	9	0	0	15	12
	Southwest	P	10	15	0	0	15	13
	Northwest	P	10	10	0	0	15	17
Iowa:	Des Moines	P	1	6	0 (4)	0	0 (4)	3
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita	P	8	5	0 (4)	0	0 (4)	1
Ky:	Louisville	P	7	6	0 (4)	0	4 (4)	5
La:	New Orleans	P	15	16	0	0	12	17
Maine:	Portland	P	9	11	0 (4)	0	23 (4)	23
Md:	Baltimore	P	6	9	0 (4)	0	12 (4)	7
Mass:	Boston	P	10	11	0 (4)	0	12 (4)	21
Mich:	Detroit	P	8	6	0 (4)	0	20 (4)	9
	Grand Rapids	P	8	10	0 (4)	0	7 (4)	12
	Bay City	P	6	6	0 (3)	0	15	9
	Charlevoix	P	13	11	0 (3)	0	16	16
	Detroit	P	7	6	0 (4)	0	6	6
	Grand Rapids	P	9	8	0 (3)	0	6	12
	Lansing	P	10	7	0 (3)	0	8	13
	Marquette	P	13	11	0 (3)	1	21	25
	Monroe	P	6	6	0 (3)	0	6	3
	South Haven	P	NS	7	NS	0	NS	10
Minn:	Minneapolis	P	5	10	0 (4)	0	11 (4)	8
	Bemidji	P	13	17	0	0	20	26
	Mankato	P	4	8	0	0	8	11
	Rochester	P	6	8	0	0	6	9
	Duluth	P	13	16	0	0	18	21
	Worthington	P	4	7	0	0	9	7
	Minneapolis	P	9	13	0	0	12	22
	Fergus Falls	P	4	9	0	0	6	10
	Little Falls	P	6	9	0	0	12	10
Miss:	Jackson	P	9	12	0 (4)	0	11 (4)	13
Mo:	Kansas City	P	7	8	0 (4)	0	6 (4)	1
	St. Louis	P	8	6	0 (4)	0	3 (4)	2
Mont:	Helena	P	4	5	0 (4)	0	4 (3)	3
Nebr:	Omaha	P	4	6	0 (3)	0	0 (3)	1
Nev:	Las Vegas	P	0	1	0 (4)	0	0 (4)	0

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for February 1970 and the 12-month period, March 1969 through February 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H:	Manchester[c]	P	10	8	0 (4)	0	16 (4)	19
N.J:	Trenton[c]	P	10	9	0 (4)	0	6 (4)	7
N.Mex:	Albuquerque[c]	P	5	3	0 (4)	0	0 (4)	0
N.Y:	Buffalo[c]	P	6	7	0 (4)	0	7 (4)	8
	New York City[c]	P	7	10	0 (4)	0	15 (4)	13
	Syracuse[c]	P	6	7	0 (3)	0	5 (3)	10
	Albany	P	NA	8	0 (3)	0	(e) (3)	(e)
	Buffalo	P	(e)	(e)	0 (4)	0	(e) (4)	(e)
	Massena	P	12	10	0	0	(e) (1)	(e)
	Newburg	P	(e)	10	0	0	(e) (1)	(e)
	New York City	P	6	10	0 (4)	0	(e) (4)	(e)
	Syracuse	P	8	7	0	0	(e) (1)	(e)
N.C:	Charlotte[c]	P	10	12	0 (4)	0	12 (4)	12
N.Dak:	Minot[c]	P	13	10	0 (4)	0	16 (4)	13
Ohio:	Cincinnati[c]	P	7	8	0 (4)	0	3 (4)	2
	Cleveland[c]	P	7	9	0 (4)	0	9 (4)	6
Okla:	Oklahoma City[c]	P	7	7	0 (4)	0	11 (4)	9
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	5	6	0 (3)	0	12 (3)	6
	Baker	P	NA	2	(e)	(e)	(e)	3
	Coos Bay	P	NA	6	(e)	(e)	(e)	10
	Eugene	P	NA	4	(e)	(e)	17	8
	Medford	P	NA	2	(e)	(e)	(e)	13
	Portland composite	P	NA	4	(e)	(e)	5 (3)	6
	Portland local	P	1	5	(e)	(e)	(e) (3)	7
	Redmond	P	NA	2	(e)	(e)	(e)	4
	Tillamook	P	NA	6	(e)	(e)	(e)	12
Pa:	Philadelphia[c]	P	7	9	0 (4)	0	4 (4)	4
	Pittsburgh[c]	P	11	11	0 (4)	0	6 (4)	8
	Dauphin	P	13	7	13	1	22	14
	Erie	P	16	10	0	6	26	23
	Philadelphia	P	13	8	0	5	28	12
	Pittsburgh	P	18	11	12	3	15	18
R.I:	Providence[c]	P	8	9	0 (4)	0	15 (4)	16
S.C:	Charleston[c]	P	8	10	0 (4)	0	15 (4)	23
S.Dak:	Rapid City[c]	P	9	8	0 (4)	0	0 (4)	4
Tenn:	Chattanooga[c]	P	9	10	0 (4)	0	12 (4)	13
	Memphis[c]	P	8	9	0 (4)	0	6 (4)	4
	Chattanooga	P	8	13	0 (4)	0	12 (4)	14
	Clinton	P	11	15	0 (2)	0	0 (2)	12
	Knoxville	P	7	10	0 (2)	0	0 (2)	4
	Nashville	P	8	8	0 (2)	0	12 (2)	5
Tex:	Austin[c]	P	0	2	0 (3)	0	0 (3)	4
	Dallas[c]	P	6	6	0 (4)	0	12 (4)	6
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R	8	5	0	0	10	2
	El Paso	R	2	2	0	0	0	0
	Fort Worth	R	NS	6	NS	0	NS	5
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	NS	8	NS	0	NS	15
	Lubbock	R	3	4	0	0	0	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	10	NS	0	NS	13
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	10	7	0	0	10	8
Utah:	Salt Lake City[c]	P	4	4	0 (4)	0	3 (4)	4
Vt:	Burlington[c]	P	7	8	0 (4)	0	6 (4)	13
Va:	Norfolk[c]	P	9	10	0 (4)	0	13 (4)	8
Wash:	Seattle[c]	P	5	7	0 (4)	0	0 (4)	10
	Spokane[c]	P	6	6	0 (3)	0	0 (3)	3
	Benton County	R	NS	1	NS	0	NS	7
	Franklin County	R	0	2	0	0	11	2
	Sandpoint, Idaho	R	6	11	0	0	0	20
	Skagit County	R	6	7	0	0	0	13
W.Va:	Charleston[c]	P	6	9	0 (3)	0	5 (3)	6
Wisc:	Milwaukee[c]	P	6	7	0 (4)	0	10 (4)	10
Wyo:	Laramie[c]	P	5	5	0 (4)	0	8 (4)	4
CANADA:								
Alberta:	Calgary	P	8	8	(d)		17	16
	Edmonton	P	6	7	(d)		19	14
British Columbia:	Vancouver	P	8	·10	(d)		22	21
Manitoba:	Winnipeg	P	8	8	(d)		16	24

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for February 1970 and the 12 month period, March 1969 through February 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
New Brunswick:	Fredericton	P	12	13	(d)		25	18
Newfoundland:	St. Johns	P	14	17	(d)		21	23
Nova Scotia:	Halifax	P	10	10	(d)		24	20
Ontario:	Ft. William	P	10	15	(d)		19	29
	Ottawa	P	6	8	(d)		12	13
	Sault Ste. Marie	P	13	14	(d)		30	29
	Toronto	P	6	5	(d)		11	10
	Windsor	P	4	5	(d)		9	11
Quebec:	Montreal	P	6	8	(d)		15	17
	Quebec	P	8	11	(d)		25	25
Saskatchewan:	Regina	P	8	7	(d)		11	13
	Saskatoon	P	4	7	(d)		10	11
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	0	0	0	0	0	3
Chile:	Santiago	P	0	0	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	2	4	0	0	60	87
Venezuela:	Caracas	P	3	2	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	0	0 (4)	0	12 (4)	9
Puerto Rico:	San Juan[c]	P	4	3	0 (4)	0	9 (4)	7
PMN network average[f]			6	7	0	0	8	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—30 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote c.
NA, no analysis.
NS, no sample collected.

1970 were below the respective practical reporting levels. Strontium-89 was detected at Del Norte, Calif., 12 pCi/liter (State sample) and Minneapolis, Minn., 9 pCi/liter (PMN).

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for the month of February 1970, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif; State sample), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 53 pCi/liter in the United States for the month of February 1970, and the highest 12-month average was 84 pCi/liter (Southeast Fla.) representing 2.3 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below the practical reporting level, with the following exceptions: Pa., Dauphin (State sample) 13 pCi/liter; Pittsburgh (State sample) 12 pCi/liter.

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California State Department of Health

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Division of Air, Occupational, and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
Connecticut Diet Study	July–December 1968 and January–June 1969	February 1970
California Diet Study	October–December 1968 and January–March 1969	May 1970

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1. Radionuclides in Institutional Diet Samples July–September 1969

Bureau of Radiological Health and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Office of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in fifty municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen

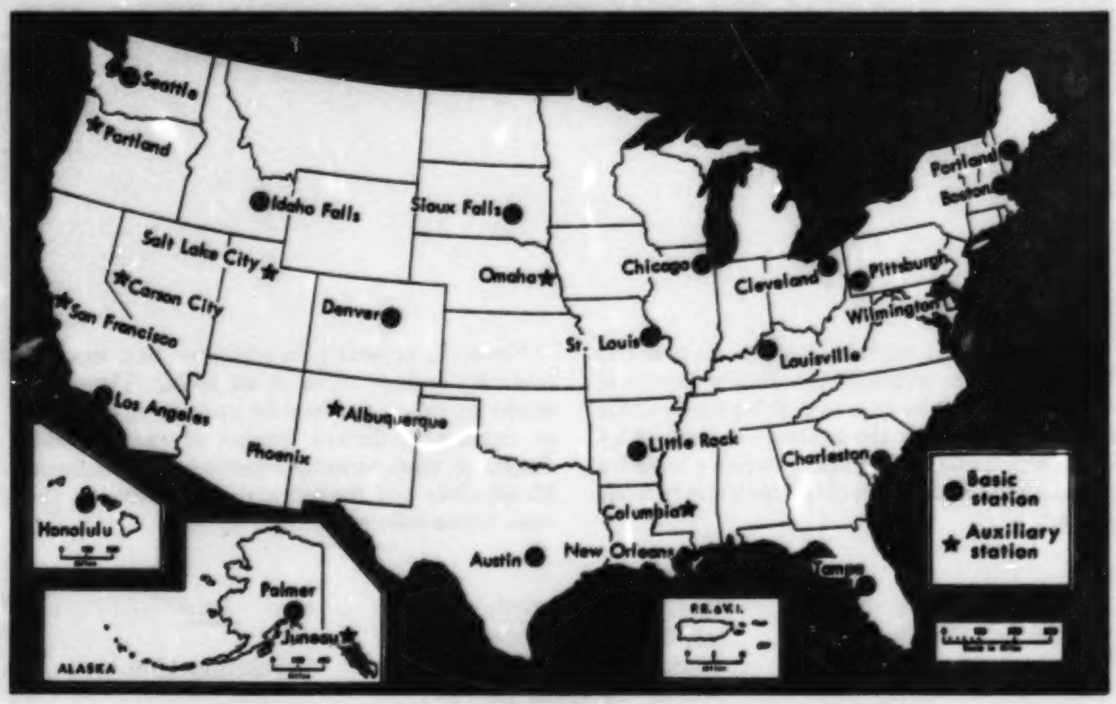
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Omaha
Carson City
San Francisco
Denver
Chicago
Cleveland
Pittsburgh
Portland
Boston
Wilmington
St. Louis
Louisville
Los Angeles
Albuquerque
Phoenix
Little Rock
Charleston
Columbia
Austin
New Orleans
Tampa
Honolulu
Palmer
Juneau
ALASKA
P.R. & V.I.
Basic station
Auxiliary station

Figure 1. Institutional diet sampling locations as of June 1969

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), July–September 1969[a]

Location of institution	Month (1969)	Total weight (kg/day)	Calcium[b] (g/kg)	Calcium[b] (g/day)	Potassium (g/kg)	Potassium (g/day)	^{89}Sr[b] (pCi/kg)	^{89}Sr[b] (pCi/day)	^{90}Sr[b] (pCi/kg)	^{90}Sr[b] (pCi/day)	^{137}Cs (pCi/kg)	^{137}Cs (pCi/day)
Alaska: Palmer	July[c]	1.54	0.5	0.8	1.1	1.7	0	0	5	7	0	0
	Aug[c]	1.37			1.1	1.5					0	0
	Sept	1.51			1.4	2.1					18	27
Ariz: Phoenix	July	1.81	.6	1.1	1.5	2.7	0	0	0	0	0	0
	Aug	1.64			1.7	2.7					0	0
	Sept	1.89			1.5	2.8					0	0
Ark: Little Rock[d]	Aug[c]	.95	.5	.7	1.3	1.2	NA	NA	8	10	0	0
	Sept[c]	1.59			1.5	2.4					0	0
Calif: Los Angeles	July[c]	1.50	.4	.6	1.1	1.7	0	0	3	4	0	0
	Aug[c]	1.51			1.1	1.7					0	0
	Sept[c]	1.26			1.3	1.6					0	0
Colo: Denver	NS											
Del: Wilmington[d]	Aug	2.14	.6	1.3	1.6	3.4	NA	NA	8	16	0	0
	Sept	1.81			1.7	3.1					0	0
Fla: Tampa	July[c]	1.28	.5	.7	1.4	1.8	NA	NA	6	9	24	30
	Aug	1.68			1.6	2.7					36	60
	Sept	1.20			1.5	1.8					35	42
Hawaii: Honolulu	July[c]	2.45	.4	1.1	1.4	2.8	0	0	2	6	0	0
	Aug[c]	2.40			1.4	3.4					26	62
	Sept	2.28			1.5	3.3					0	0
Idaho: Idaho Falls	July[c]	1.97	1.0	1.9	1.5	3.0	0	0	8	16	16	32
	Aug[c]	2.05			1.5	3.0					13	26
	Sept[c]	1.85			1.6	2.9					0	0
Ill: Chicago	NS											
Ky: Louisville[d]	Aug	2.89	.6	1.8	1.6	4.7	NA	NA	8	23	12	35
	Sept	2.74			1.9	5.1					0	0
La: New Orleans	July	1.96	.5	1.1	1.6	3.1	0	0	9	18	0	0
	Aug	2.08			1.6	3.3					0	0
	Sept[c]	2.16			1.7	3.6					22	48
Maine: Portland	July	1.91	.7	1.3	1.6	3.1	NA	NA	10	18	17	32
	Aug	1.65			1.6	2.6					20	33
	Sept	1.70			1.3	2.2					15	26
Mass: Boston	July	2.26	.6	1.3	1.8	4.0	6	13	9	20	21	47
	Aug	2.19			1.7	3.7					18	39
	Sept	2.19			1.8	3.9					19	42
Mo: St. Louis	July[c]	2.60	.8	2.0	1.7	4.4	NA	NA	7	17ʹ	11	29
	Aug[c]	2.23			1.6	3.6					0	0
	Sept[c]	2.42			1.7	4.1					0	0
Ohio: Cleveland	July	1.90	.7	1.2	1.6	3.0	NA	NA	7	12	11	21
	Aug	1.53			2.0	3.0					11	17
	Sept	1.78			1.7	3.0					0	0
Pa: Pittsburgh	July	2.26	.5	1.1	1.4	3.2	NA	NA	8	16	0	0
	Aug	2.32			1.2	2.8					0	0
	Sept	2.37			1.3	3.0					0	0
S.C: Charleston	July	1.18	.6	.7	1.2	1.4	NA	NA	8	11	18	21
	Aug	1.12			1.3	1.5					16	18
	Sept	2.17			1.2	2.6					0	0
S. Dak: Sioux Falls	July	1.55	.6	1.0	1.2	1.8	NA	NA	6	9	0	0
	Aug	1.49			1.3	1.9					0	0
	Sept	1.66			1.2	2.0					0	0
Tex: Austin	July[c]	1.70	.8	1.5	1.5	2.6	NA	NA	4	7	0	0
	Aug[c]	1.79			1.5	2.7					0	0
	Sept[c]	2.18			1.6	3.5					0	0
Wash: Seattle	July[c]	1.77	.5	1.0	1.5	2.6	0	0	5	9	0	0
	Aug[c]	1.90			1.7	3.2					11	21
	Sept[c]	1.79			1.4	2.6					0	0
Institutional average	July	1.85	0.6	1.2	1.5	2.8	0	0	6	12	8	15
	Aug	1.86			1.6	2.9					10	18
	Sept	1.93			1.5	2.9					7	11

[a] Iodine-131 and barium-140 were not detected at any station during this period therefore no provision was made for these nuclides in this table.

[b] Composite analysis of quarterly samples for each station.

[c] Since food samples were collected from two or more children who were not between the ages of 9 to 12, the gamma analyses for this month were not used in the institutional average. The chemistry data was included in the institutional average since this analysis was a composite of three or less individual samples.

[d] The samples for Little Rock, Ark.; Wilmington, Del.; and Louisville, Ky. were not collected for the month of July.

NA, no analysis.

NS, no sample.

until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from July through September 1969 for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples reported in pCi/kg of diet, are corrected for

Table 2. Concentration and intake of stable elements and radionuclides in institutional total diets of individuals July–September 1969[a]

Location of institution	Month (1969)	Total weight (kg/day)	Calcium[b] (g/kg)	Calcium[b] (g/day)	Potassium (g/kg)	Potassium (g/day)	^{89}Sr[b] (pCi/kg)	^{89}Sr[b] (pCi/day)	^{90}Sr[b] (pCi/kg)	^{90}Sr[b] (pCi/day)	^{137}Cs (pCi/kg)	^{137}Cs (pCi/day)
Alaska: Juneau	July	0.89	0.6	0.6	2.0	1.7	11	10	14	13	0	0
	Aug	.87			1.2	1.1					16	14
	Sept	.87			1.5	1.3					13	11
Calif: Oakland	July	2.17	.7	1.5	1.8	3.9	0	0	3	7	0	0
	Aug	2.11			1.8	3.8					12	25
	Sept	1.77			1.6	2.8					0	0
Miss: Columbia	July	2.41	.9	1.9	1.5	3.6	NA	NA	5	12	18	43
	Aug	2.00			1.3	2.6					46	92
	Sept	2.21			1.4	3.2					11	24
Neb: Omaha	July	2.30	.8	1.8	1.8	4.1	NA	NA	6	14	11	25
	Aug	2.60			1.7	4.4					0	0
	Sept	2.13			1.7	3.6					0	0
Nev: Carson City	July	1.19	.9	1.2	1.2	1.5	0	0	4	5	14	17
	Aug	1.61			1.2	2.0					13	21
	Sept	1.26			1.1	1.4					0	0
N.Mex: Albuquerque	July	2.53	.8	1.8	1.6	4.0	NA	NA	2	5	0	0
	Aug	2.06			1.4	2.9					0	0
	Sept	2.23			1.6	3.6					0	0
Ore: Portland	July	1.71	.6	1.0	1.9	3.2	0	0	5	9	0	0
	Aug	1.94			2.0	3.8					12	23
	Sept	2.06			1.7	3.4					0	0
Utah: Salt Lake City	July	2.47	.5	1.2	1.2	3.0	0	0	3	7	12	30
	Aug	2.38			1.2	2.9					0	0
	Sept	2.49			1.4	3.5					0	0
Institutional average	July	1.98	0.7	1.4	1.6	3.1	2	2	5	9	7	14
	Aug	1.95			1.5	2.9					12	22
	Sept	1.88			1.5	2.9					3	4

[a] Concentrations for iodine-131 and barium-140 in pCi/kg were below detectable levels and reported as zero.
[b] Composite analysis of quarterly samples for each station.
NA, no analysis.

radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.89 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium-90 dietary intake during this period averaged 12 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 15 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1968	July 1969
January–March 1969 and Annual Summary 1968	October 1969
April–June 1969	January 1970

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2. Strontium-90 in Tri-City Diets January–December 1969

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*5*). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*6*).

Starting in 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*7*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1969 in New York City and San Francisco.

Results for January–December 1969 are presented in tables 3 through 6. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 2.

Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet February–March 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City Febuary 1969 Strontium-90 (pCi/kg)	New York City Febuary 1969 Strontium-90 (pCi/a)	San Francisco March 1969 Strontuim-90 (pCi/kg)	San Francisco March 1969 Strontuim-90 (pCi/a)
Dairy products	200	216.0	7.5	1,500	2.4	480
Fresh fruit	59	9.4	15.8	932	3.4	201
Fresh vegetables	48	18.7	10.9	523	2.7	130
Root vegetables	10	3.8	6.8	68	6.5	65
Potatoes	38	3.8	4.7	170	3.3	125
Macaroni	3	.6	3.8	11	2.2	7
Rice	3	1.1	1.8	5	1.6	5
Fruit juices	28	2.5	3.0	84	3.6	101
Canned vegetables	22	4.4	7.7	169	2.3	51
Canned fruit	11	.6	1.5	17	.8	9
Dried beans	3	2.1	7.5	23	10.3	31
Flour	34	6.5	7.2	245	3.0	102
Bakery products	44	53.7	6.5	286	3.8	167
Whole grain products	11	10.3	13.8	64	11.0	121
Fresh fish	8	7.6	.7	6	.4	3
Shellfish	1	1.6	.9	1	.3	
Poultry	20	6.0	1.2	24	1.1	22
Meat	79	12.6	.9	71	.3	24
Eggs	15	8.7	1.6	24	1.4	21
Annual intake (pCi/a)		370		4,252		1,666
Daily intake (pCi/day)				11.6		4.6

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[1] Data from Fallout Program Quarterly Summary Report, HASL 214, 217, 224. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

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Table 4. Average dietary consumption and strontium-90 intake in Tri-City diet May–June 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City May 1969		San Francisco June 1969	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	10.1	2,020	2.9	580
Fresh fruit	59	9.4	8.2	484	2.2	130
Fresh vegetables	48	18.7	17.1	821	2.4	115
Root vegetables	10	3.8	10.9	109	3.2	32
Potatoes	38	3.8	6.0	228	3.6	137
Macaroni	3	.6	4.5	14	2.7	8
Rice	3	1.1	1.3	4	1.5	5
Fruit juices	28	2.5	2.7	76	1.5	42
Canned vegetables	22	4.4	12.2	268	2.2	48
Canned fruit	11	.6	1.7	19	.8	9
Dried beans	3	2.1	6.6	20	12.6	38
Flour	34	6.5	5.4	184	3.0	102
Bakery products	44	53.7	5.2	229	3.6	158
Whole grain products	11	10.3	13.4	147	10.2	113
Fresh fish	8	7.6	.3	2	.2	2
Shellfish	1	1.6	.7	1	.5	1
Poultry	20	6.0	.9	18	.4	8
Meat	79	12.6	1.3	103	.3	24
Eggs	15	8.7	1.0	15	1.8	27
Annual intake (pCi/a)		370		4,762		1,579
Daily intake (pCi/day)				13.0		4.3

Table 5. Average dietary consumption and strontium-90 intake in Tri-City diet August–September 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York August 1969		San Francisco September 1969	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	9.6	1,920	1.6	320
Fresh fruit	59	9.4	3.0	177	2.2	130
Fresh vegetables	48	18.7	12.6	605	2.2	106
Root vegetables	10	3.8	2.6	26	5.4	54
Potatoes	38	3.8	4.4	167	.7	27
Macaroni	3	.6	4.2	13	3.8	11
Rice	3	1.1	1.2	4	2.3	7
Fruit juices	28	2.5	5.6	157	2.0	56
Canned vegetables	22	4.4	14.2	312	1.9	42
Canned fruit	11	.6	1.6	18	1.3	14
Dried beans	3	2.1	17.9	54	13.4	40
Flour	34	6.5	7.1	241	3.0	102
Bakery products	44	53.7	6.5	286	4.9	216
Whole grain products	11	10.3	1.8	20	11.0	121
Fresh fish	8	7.6	1.9	15	.3	2
Shellfish	1	1.6	1.1	1	.4	
Poultry	20	6.0	1.7	34	1.2	24
Meat	79	12.6	1.3	103	5.8	458
Eggs	15	8.7	2.7	41	2.4	36
Annual intake (pCi/a)		370		4,194		1,766
Daily intake (pCi/day)				11.5		4.8

Table 6. Average dietary consumption and strontium-90 intake in Tri-City diet November–December 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City November 1969		San Francisco December 1969	
			Strontium 90		Strontium 90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	9.2	1,840	2.1	420
Fresh fruit	59	9.4	10.5	620	3.1	183
Fresh vegetables	48	16.7	18.1	869	4.0	192
Root vegetables	10	3.8	7.8	78	4.5	45
Potatoes	38	3.8	6.5	247	1.1	42
Macaroni	3	.6	4.0	12	3.1	9
Rice	3	1.1	1.7	5	2.5	8
Fruit juices	28	2.5	3.7	104	1.8	50
Canned vegetables	22	4.4	8.2	180	3.4	75
Canned fruit	11	.6	1.7	19	1.1	12
Dried beans	3	2.1	36.8	110	11.1	33
Flour	34	6.5	5.5	187	3.8	129
Bakery products	44	53.7	6.5	286	4.4	194
Whole grain products	11	10.3	16.2	178	6.8	75
Fresh fish	8	7.6	.3	2	.3	2
Shellfish	1	1.6	1.6	2	.6	1
Poultry	20	6.0	.7	14	1.7	34
Meat	79	12.6	.5	40	.4	32
Eggs	15	8.7	1.7	26	2.5	38
Annual intake (pCi/a)		370		4,819		1,574
Daily intake (pCi/day)				13.0		4.2

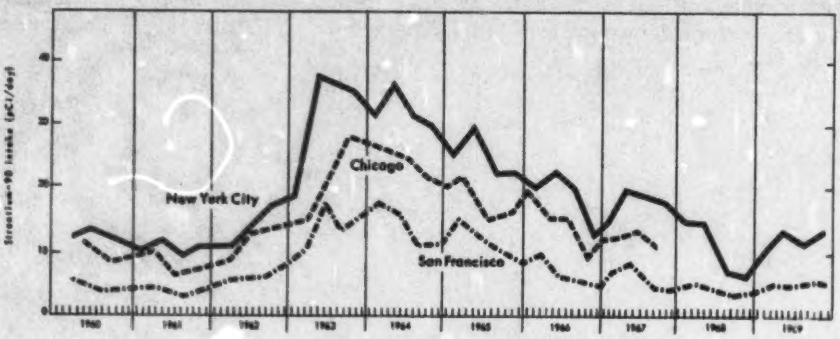

Figure 2. Daily intake of strontium-90 in Tri-City diets March 1960–December 1969

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	April 1969
July–December 1968	December 1969

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(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(5) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(6) RIVERA, J. and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-137. Office of Technical Services, U. S. Atomic Energy Commission, New York, N. Y. (July 1, 1964).

(7) U.S. DEPARTMENT OF AGRICULTURE. Food Consumption of Households in the United States, Spring 1965. A Preliminary Repor USDA, ARS 62-16 (August 1967.)

SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Coast Guard Water Supplies	January 1968–July 1969	February 1970
Florida	1968	March 1970
Minnesota	January–June 1969	January 1970
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

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(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Radioactivity in New York Surface Water January–June 1969

Division of General Engineering and
Radiological Health
State of New York Department of Health

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations.

Analytical procedures

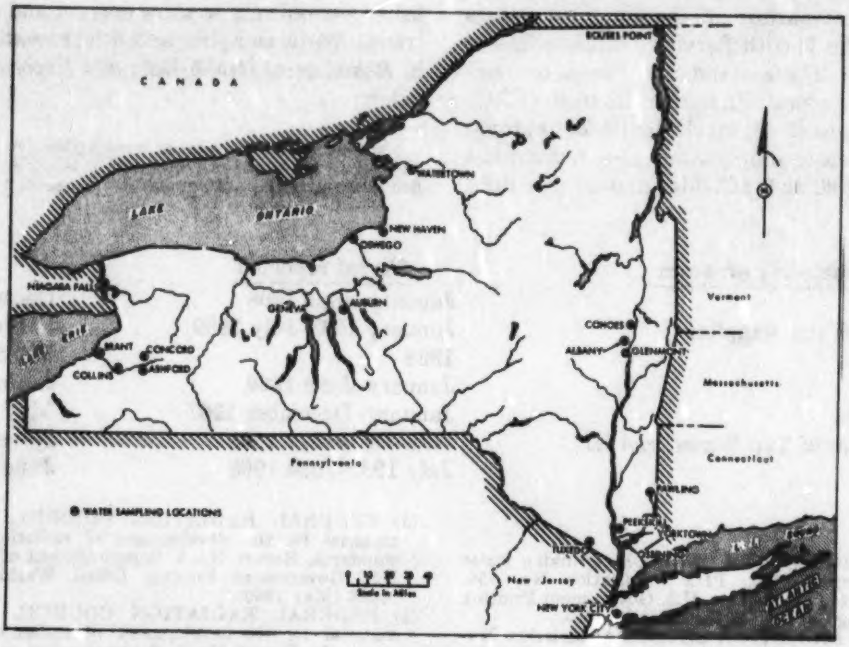
A measured quantity of water, usually 500 ml, is evaporated and the residue is analyzed for its gross beta component in an end-window, gas-flow, proportional counter.

Strontium and alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1–2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium radioactivity and that of strontium-90.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Tritium in water is determined by liquid scintillation counting of 3 ml of distilled sample in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OSWEGO
NIAGARA FALLS
LAKE ERIE
GENEVA
AUBURN
BRANT
CONCORD
COLLINS
ASHFORD
COHOES
ALBANY
GLENMONT
Vermont
Massachusetts
Connecticut
Pennsylvania
PAWLING
PEEKSKILL
YORKTOWN
OSSINING
TUXEDO
New Jersey
NEW YORK CITY
ATLANTIC OCEAN
● WATER SAMPLING LOCATIONS
Scale in Miles

Figure 1. New York water sampling locations

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17 ml of scintillator solution. The scintillator solution consists of 4 g PPO, 0.25 g dimethyl POPOP and 120 g naphthalene dissolved in 1 liter of dioxane. The sample is counted twice for a total of 100 minutes using either a Packard Tri-Carb model 3315 or a Beckman LS 200B liquid scintillation spectrometer. Minimum sensitivities at the 95-percent confidence level ± 100 percent are 1,000 pCi/liter for the Tri-Carb and 500 pCi/liter for the Beckman.

Discussion and results

With the exception of Buttermilk and Cattaraugus Creeks downstream from Nuclear Fuel Services, the results of water sampling stations in the State remain low. Water samples are obtained from 23 locations for gross beta-particle analysis (figure 1). The type of sample, number of samples, quarterly average, maximum and minimum gross beta-particle concentrations in New York surface water for January–June 1969 are given in table 1.

Table 1. Gross beta radioactivity in New York raw surface water, January–June 1969[a]

Location	Gross beta radioactivity (pCi/liter)							
	January–March 1969				April–June 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	4	3	3	2	3	2	2	2
Ashford (Buttermilk Creek at Fox Valley Road)	3	7	9	4	3	4	5	3
(Buttermilk Creek at Thomas Corners)[b]	12	1,317	5,163	298	16	1,042	3,488	73
(Cattaraugus Creek)	3	6	11	3	3	5	9	3
Brant (Cattaraugus Creek)	6	116	443	28	13	75	286	16
Cohoes (Filtration Plant)[c]	13	3	4	ND	11	4	13	ND
Collins (Cattaraugus Creek)	13	80	158	24	13	110	323	16
Concord (Cattaraugus Creek)	66	147	584	32	62	124	563	ND
Geneva (Seneca Lake)	4	4	4	3	2	5	8	3
Glenmont (Hudson River)	15	3	7	ND	13	4	6	2
New Haven (Lake Ontario)	0	NA	NA	NA	3	4	4	3
New York City	8	2	4	ND	5	3	4	2
Niagara Falls (West Branch Niagara River)	5	4	5	3	3	4	4	4
Ossining (Indian Brook Reservoir)	3	5	6	4	3	2	4	ND
(Sing Sing) (Hudson River)	15	18	70	ND	13	8	23	ND
Oswego	3	4	4	3	3	3	4	3
Pawling (Pond at United Nuclear)	3	3	3	3	3	4	4	3
Peekskill (Camp Field Water Supply)	3	3	8	ND	3	5	15	ND
(Hudson River)	14	8	32	ND	13	3	6	ND
New Haven (Ontario)	0	NA	NA	NA	3	4	4	3
Tuxedo (Indian Kill)	3	4	5	3	1	7	7	7
Watertown (Black River)	3	3	4	2	3	3	4	3
Yorktown (Croton Reservoir)	3	3	5	ND	3	4	6	3

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
[c] After June 16, 1969 this station will be replaced by Crescent Water Trailer.
NA, no analysis. ND, nondetectable.

Table 2. Cesium-137 and strontium-90 in New York surface waters, January–June 1969

Location	January–March 1969							April–June 1969						
	Number of samples	Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)			Number of samples	Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)		
		Average	Maximum	Minimum	Average	Maximum	Minimum		Average	Maximum	Minimum	Average	Maximum	Minimum
Ashford														
(Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
(Buttermilk Creek at Thomas Corners)[a]	12	319	1,161	20	489	1,368	120	15	38	155	ND	142	328	28
(Cattaraugus Creek)	3	ND	ND	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
Brant														
Cattaraugus Creek)	1	273			60			10	ND	ND	ND	10	18	ND
Collins														
(Cattaraugus Creek)	0	NA	NA	NA	NA	NA	NA	11	ND	100	ND	13	28	7
Concord														
(Springville Power Dam on Cattaraugus Creek)	12	46	161	ND	55	79	16	18	ND	ND	ND	15	47	ND
Ossining (Sing Sing)														
(Hudson)	15	ND	ND	ND	NA	NA	NA	13	ND	ND	ND	ND	ND	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
NA, no analysis. ND, nondetectable.

Larger samples are collected at selected locations for strontium-90 analysis. The number of samples, average, maximum, and minimum concentrations of strontium-90 and cesium-137 in New York water for January–June 1969 are given in table 2 for those stations where strontium-90 and cesium-137 was detected.

Tritium concentration values for January–June 1969 are given in table 3 for eight locations. Tritium, a very low energy beta-particle emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks showed the contribution of the Nuclear Fuels Services reprocessing plant.

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(2) WELFORD, G. and D. SUTTON. A paper presented at the American Chemical Society meeting in New York City, September 1960.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	April 1969
July–December 1968	September 1969

Table 3. Tritium concentration of New York surface waters, January–June 1969

Location	Concentration (nCi/liter)							
	January–March 1969				April–June 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	4	1.05	2.69	ND	3	ND	ND	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners Road)[a]	12	132	431	5.99	16	73.2	324	1.30
Cattaraugus Creek at Bigelow Bridge	3	ND	1.80	ND	3	ND	1.12	ND
Brant (Cattaraugus Creek)	6	9.70	17.5	1.79	13	6.43	26.7	ND
Cohoes (Filtration Plant)	13	ND	2.10	ND	11	ND	1.05	ND
Collins (Cattaraugus Creek)	13	13.0	44.5	ND	13	10.2	27.6	ND
Concord (Springville Power Dam on Cattaraugus Creek)	66	18.8	73.6	ND	62	10.2	46.3	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	July–September 1968	February 1970

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1. Radiation Alert Network
February 1970

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during February 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

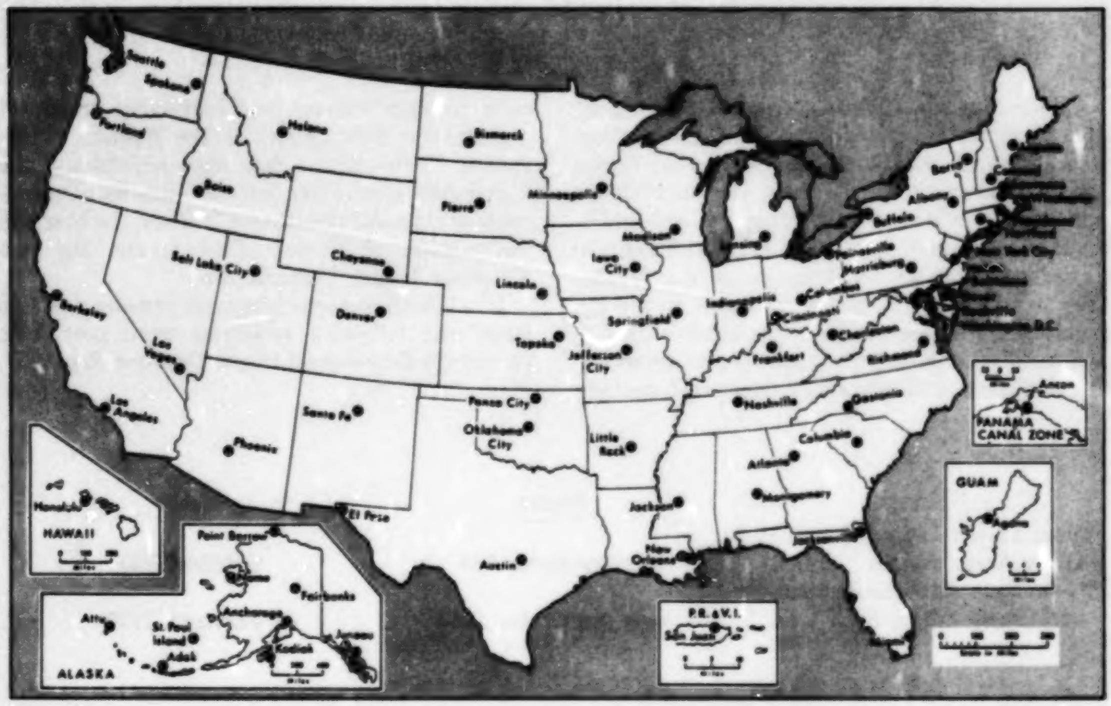
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Las Vegas
Topeka
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
El Paso
Austin
HAWAII
Honolulu
ALASKA
Point Barrow
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Madison
Iowa City
Lansing
Springfield
Jefferson City
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Richmond
Buffalo
Albany
Barre
Augusta
Concord
Painesville
Harrisburg
New York City
Washington, D.C.
Nashville
Gastonia
Little Rock
Columbia
Atlanta
Montgomery
Jackson
New Orleans
PANAMA CANAL ZONE
Ancon
GUAM
Agana
P.R. & V.I.
San Juan

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1970

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	17	2	0	1	Dec 69	4	96	4	96	30
Alaska:	Adak	(b)				Dec 69	(c)				
	Anchorage	16	0	0	0	June 70	(c)				
	Attu Island	22	0	0	0	Jan 70	(c)				
	Fairbanks	13	0	0	0	Sept 69	3	7	3	7	4
	Juneau	10	8	0	2	Oct 69	6	78	6	78	0
	Kodiak	(b)				Nov 69	(c)				
	Nome	13	2	0	1	Mar 70	(c)				
	Point Barrow	(b)				Feb 70	(c)				
	St. Paul Island	(b)				Apr 70	(c)				
Ariz:	Phoenix	16	14	1	7	Oct 69	(c)				
Ark:	Little Rock	(b)				June 70	(c)				
Calif:	Berkeley	19	1	0	0	Nov 69	4	31	4	31	0
	Los Angeles	14	5	1	2	Mar 70	(c)				
C.Z:	Ancon	14	0	0	0	Nov 69	(c)				
Colo:	Denver	17	3	1	2	Nov 69	(c)				
Conn:	Hartford	16	0	0	0	Sept 69	5	65	5	65	0
Del:	Dover	17	1	0	0	May 70	(c)				
D.C:	Washington	26	1	0	0	Feb 70	(c)				
Fla:	Jacksonville	16	4	0	1	June 70	5	110	5	110	8
	Miami	16	0	0	0	Sept 69	3	48	3	48	0
Ga:	Atlanta	19	1	1	1	Apr 70	2	92	2	92	27
Guam:	Agana	(b)				May 70	(c)				
Hawaii:	Honolulu	22	2	0	1	Jan 70	(c)				
Idaho:	Boise	18	3	0	2	Jan 70	3	15	3	15	0
Ill:	Springfield	13	1	0	1	Feb 70	(c)				
Ind:	Indianapolis	(b)				Apr 70	(c)				
Iowa:	Iowa City	16	1	0	0	Nov 69	2	9	2	9	0
Kans:	Topeka	20	4	0	2	June 70	1	3	1	3	1
Ky:	Frankfort	12	1	0	0	Feb 70	(c)				
La:	New Orleans	16	1	0	0	Feb 70	5	71	(d)		
Maine:	Augusta	19	0	0	0	Mar 70	9	198	9	198	0
Md:	Baltimore	18	1	0	0	Sept 69	5	37	5	37	0
	Rockville	8	1	0	0	Jan 70	(c)				
Mass:	Lawrence	18	0	0	0	May 70	4	104	4	104	0
	Winchester	19	1	0	0	Dec 69	4	106	4	106	0
Mich:	Lansing	15	0	0	0	Jan 70	(c)				
Minn:	Minneapolis	19	1	0	0	May 70	(c)				
Miss:	Jackson	16	2	0	1	Mar 70	3	90	3	90	0
Mo:	Jefferson City	18	2	0	1	Apr 70	2	10	2	10	0
Mont:	Helena	15	2	0	1	Dec 69	2	7	2	7	3
Nebr:	Lincoln	14	5	1	3	Apr 70	1	4	1	4	3
Nev:	Las Vegas	11	4	0	2	Sept 69	(c)				
N.H:	Concord	(b)				Feb 70	(c)				
N.J:	Trenton	18	1	0	0	Mar 70	4	60	4	60	0
N. Mex:	Santa Fe	16	3	0	1	Dec 69	2	4	2	4	0
N.Y:	Albany	7	0	0	0	Apr 70	3	25	3	25	12
	Buffalo	16	0	0	0	Nov 69	(c)				
	New York City	6	1	0	0	Dec 69	(c)				
N.C:	Gastonia	16	8	0	2	Nov 69	4	38	(d)		
N. Dak:	Bismarck	18	1	0	0	Feb 70	1	2	1	2	0
Ohio:	Cincinnati	(b)				May 70	(c)				
	Columbus	4	1	0	0	Mar 70	(c)				
	Painesville	17	1	0	0	Sept 69	9	27	9	27	6
Okla:	Oklahoma City	(b)				Jan 70	(c)				
	Ponca City	20	8	0	2	Sept 69	(c)				
Ore:	Portland	18	3	0	1	Apr 70	8	58	8	58	1
Pa:	Harrisburg	15	1	0	0	Apr 70	3	52	3	52	9
P.R:	San Juan	2	2	1	1	Mar 70	(c)				
R.I:	Providence	17	1	0	0	Jan 70	1	19	1	19	1
S.C:	Columbia	19	2	0	1	Dec 69	2	47	2	47	3
S. Dak:	Pierre	13	4	1	2	Oct 69	(c)				
Tenn:	Nashville	17	1	0	0	Jan 70	7	108	7	108	8
Tex:	Austin	11	10	1	2	May 70	3	105	(d)		
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	27	8	0	2	Mar 70	4	3	4	3	0
Vt:	Barre	12	1	0	0	June 70	7	50	7	50	9
Va:	Richmond	18	1	0	0	June 70	5	58	5	58	8
Wash:	Seattle	18	1	0	0	June 70	8	36	(d)		
	Spokane	17	2	0	1	May 70	(c)				
W. Va:	Charleston	20	2	0	0	Dec 69	9	86	9	86	5
Wis:	Madison	19	1	0	0	June 70	2	4	2	4	1
Wyo:	Cheyenne	18	7	1	2	Sept 69	1	137	1	137	1
Network summary		982	14	0	1		4	54	4	53	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

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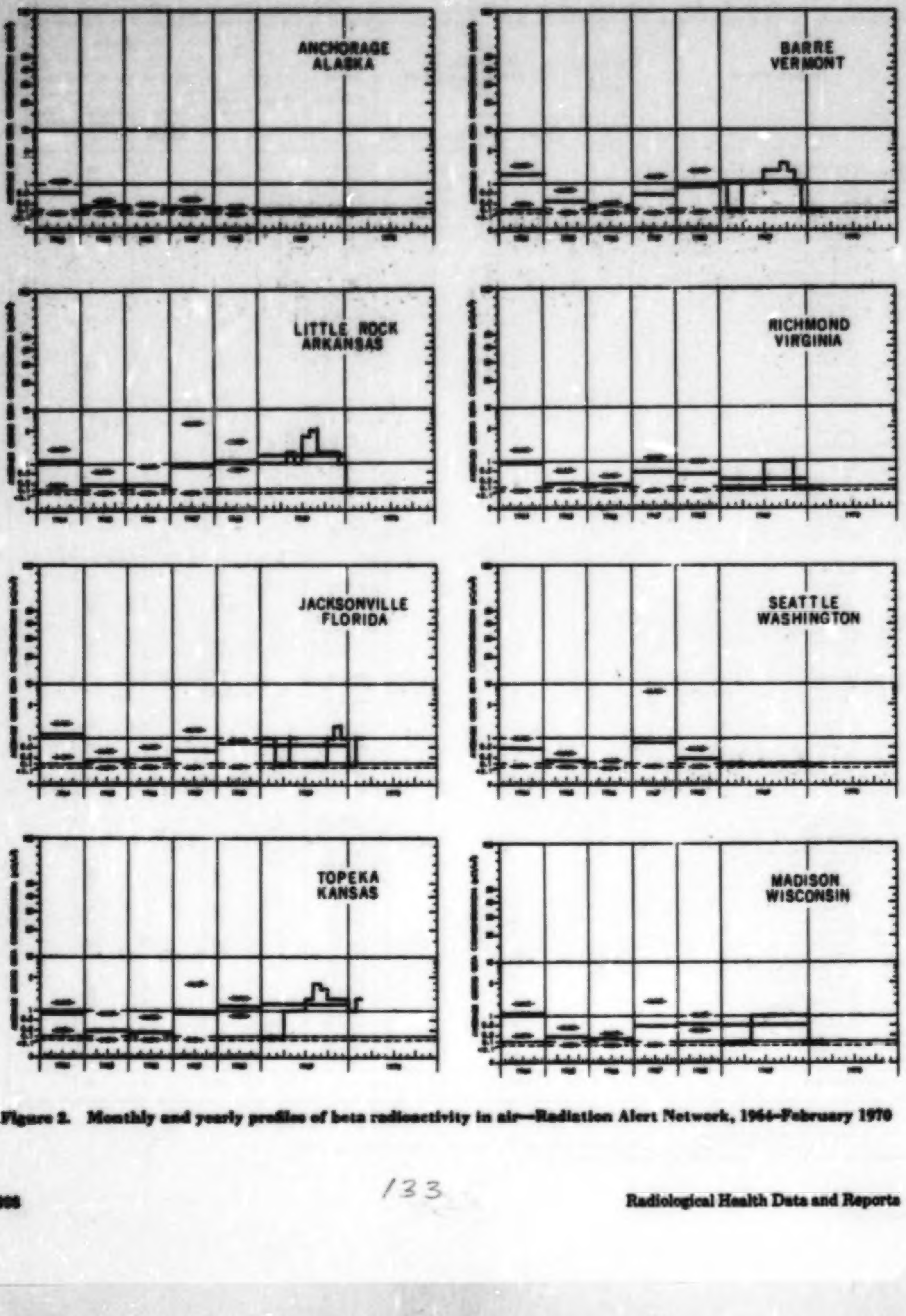

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–February 1970

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2. Canadian Air and Precipitation Monitoring Program[1], February 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for February 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1970

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.4	0.0	0.1	88	0.5
Coral Harbour	14	.1	.0	.1	57	.3
Edmonton	28	.3	.0	.1	7	.1
Ft. Churchill	27	.1	.0	.1	81	.2
Fredericton	28	.2	.0	.1	12	1.8
Goose Bay	28	.1	.0	.1	18	.9
Halifax	28	.3	.0	.1	37	3.7
Inuvik	28	.1	.0	.1	32	.3
Montreal	28	.2	.1	.1	19	.9
Moosonee	28	.3	.1	.1	5	.1
Ottawa	24	.1	.0	.1	11	1.1
Quebec	27	.1	.0	.1	NS	NS
Regina	28	.1	.0	.1	22	.7
Resolute	28	.3	.0	.1	17	.1
St. John's Nfld	28	.1	.0	.1	19	4.4
Saskatoon	28	.1	.0	.1	208	1.5
Sault St. Marie	28	.3	.0	.1	64	4.0
Thunder Bay	23	.2	.1	.1	37	.7
Toronto	27	.2	.0	.1	40	1.0
Vancouver	28	.3	.0	.1	49	2.7
Whitehorse	28	.2	.0	.1	42	.3
Windsor	28	.1	.0	.1	15	.4
Winnipeg	28	.1	.0	.1	14	.2
Yellowknife	27	.2	.1	.1	22	.3
Network summary	645	0.4	0.0	0.1	36	1.1

NS, no sample.

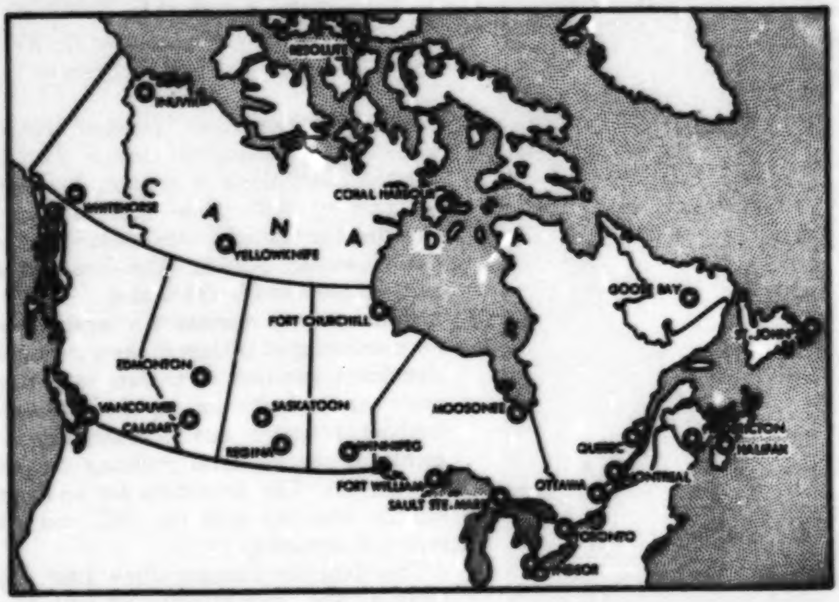
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
C A N A D A
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
MOOSONEE
VANCOUVER
CALGARY
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Air Sampling Program February 1970

Pan American Health Organization
and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The February 1970 air monitoring results from the participating countries are given in table 3.

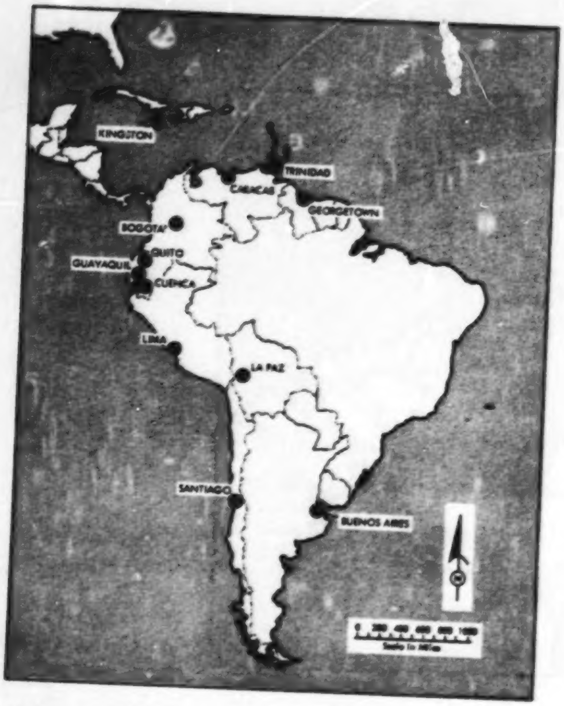

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1970

Station		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	NS	NS	NS	NS
Bolivia:	La Paz	1	0.01	0.01	0.01
Chile:	Santiago	11	.17	.02	.07
Colombia:	Bogota	20	.19	.01	.05
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	17	.12	.02	.05
	Quito	NS	NS	NS	NS
Guyana:	Georgetown	NS	NS	NS	NS
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	20	.12	.03	.07
Venezuela:	Caracas	16	.22	.01	.10
West Indies:	Trinidad	17	.12	.02	.09
Pan American summary		102	0.22	0.01	0.06

[a] The monthly average is calculated by weighting the individual sample with length of sampling period. Values less than 0.005 pCi/m³ are used in averaging as 0.00 pCi/m³.
NS, no sample.

4. Tritium in Precipitation January–June 1969

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, established a tritium in precipitation program in 1967. Nine stations were selected covering the United States, including Alaska and the Hawaiian Islands. The locations of these stations are listed in the tables.

Rain analysis represents a sensitive technique for monitoring of tritium in the environment. Any significant addition of tritium into the natural cycle can be easily and rapidly detected by rain analysis, primarily due to considerable improvements in the low-level counting techniques for tritium (*6*). The procedure for analyzing these samples and the data for 1967 and 1968 were reported previously (*7*).

The data for January–June 1969 appears in table 4. The concentration of tritium at these stations for this period remains at the same level as previously reported.

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Table 4. Tritium analysis of precipitation from RAN stations, January–June 1969

Locations	Concentration (nCi/liter)					
	January	February	March	April	May	June
N.C: Gastonia	NS	0.5	0.4	<0.2	<0.2	NS
Alaska: Anchorage	NS	< .2	NS	NS	NS	NS
Ala: Montgomery	<0.2	< .2	< .2	< .2	< .2	0.4
S. Dak: Pierre	NS	NS	NS	NS	NS	NS
La: New Orleans	NS	< .2	NS	< .2	NS	NS
Tex: Austin	NS	< .2	< .2	< .2	< .2	NS
Colo: Denver	NS	.5	.5	1.1	1.2	NS
Hawaii: Honolulu	NS	< .2	< .2	< .2	NS	NS
Wash: Seattle	NS	< .2	< .2	< .2	< .2	NS

NS, no sample.

5. Plutonium in Airborne Particulates and Precipitation, July–December 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966, respectively, and the results through September 1968 have been previously reported (*8–18*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. The laboratory reduced this analysis on filters to quarterly composites as of the August 1, 1968 sample. They also discontinued analysis of precipitation for plutonium due to consistently low levels of plutonium in the environment after September 30, 1968. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*8*).

The results for July through December 1968 are presented in tables 5 and 6. Nondetectable (ND) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples and from 2 to 8 liters for the precipitation samples.

Table 5. Plutonium in airborne particulates July–December 1968

Location	Month (1958)	Plutonium-238 (fCi/m³)	Pluotnium-239 (fCi/m³)	Plutonium-239/plutonium-238
Alaska:				
Anchorage	July	0.004	0.018	4.5
	Aug–Sept	.007	.035	5.0
	Oct–Dec	.006	.029	4.8
Ariz:				
Phoenix	July	.004	.023	5.8
	Aug–Sept	.012	.079	6.6
	Oct–Dec	.017	.067	3.9
Colo:				
Denver	July	.010	.060	6.0
	Aug–Sept	NS	NS	
	Oct–Dec	NS	NS	
Hawaii:				
Honolulu	July	.004	.016	4.0
	Aug–Sept	.004	.015	3.8
	Oct–Dec	.005	.022	4.4
La: New				
Orleans	July	.004	.026	6.5
	Aug–Sept	.013	.065	5.0
	Oct–Dec	.010	.043	4.3
Md:				
Rockville	July	NS	NS	
	Aug–Sept	[a].009	[a].056	6.2
	Oct–Dec	NS	NS	
N.Y:				
Buffalo	July	.007	.039	5.6
	Aug–Sept	.012	.059	4.9
	Oct–Dec	.024	.121	5.0
N.C:				
Gastonia	July	.009	.042	4.7
	Aug–Sept	.015	.082	5.5
	Oct–Dec	.008	.051	6.4
S. Dak:				
Pierre	July	.009	.041	4.6
	Aug–Sept	.036	.135	3.8
	Oct–Dec	NS	NS	
Tex:				
Austin	July	.004	.022	5.5
	Aug–Sept	.008	.049	6.1
	Oct–Dec	.011	.038	3.5
Wash:				
Seattle	July	.004	.027	6.8
	Aug–Sept	.006	.036	6.0
	Oct–Dec	.016	.047	2.9

[a] September sample only.
NS, no sample.

Errata: The previous tables presenting data for plutonium-238 and plutonium-239 in precipitation and airborne particulates for July–September 1968 have some errors in calculations. This data appears in *Radiological Health Data and Reports* 11:92–93 (February 1970). Incorporated in this article are corrected tables for the July–September 1968 data and additional data from October–December 1968.

Table 6. Plutonium-238 and plutonium-239 in precipitation, July–September 1968

Location	Month (1968)	Precipitation depth (mm)	Concentration (pCi/liter)		Deposition (pCi/m²)	
			Plutonium-238	Plutonium-239	Plutonium-238	Plutonium-239
Alaska: Anchorage	July	19.4	0.006	0.085	0.12	0.40
	August	23.2	ND	.013		.30
	September	18.5	ND	.018		.33
Colo: Denver	July	38.4	ND	.008		.32
	August	22.6	ND	.004		.13
	September	16.1	ND	.012		.20
Hawaii: Honolulu	July	NS	NS	NS	NS	NS
	August	NS	NS	NS	NS	NS
	September	30.0	ND	ND		
La: New Orleans	July	13.7	ND	.020		.28
	August	11.3	.011	ND	.12	
	September	46.5	.118	.085	5.46	3.95
Md: Rockville	July	NS	NS	NS	NS	NS
	August	94.6	ND	.015		1.42
	September	NS	NS	NS	NS	NS
N.C: Gastonia	July	31.8	ND	.013		.41
	August	NS	NS	NS	NS	NS
	September	26.8	.006	.008	.16	.22
Tex: Austin	July	NS	NS	NS	NS	NS
	August	13.5	ND	ND		
	September	65.3	.059	.009	3.86	.59
Wash: Seattle	July	10.8	ND	.026		.29
	August	99.6	ND	.008		.79
	September	31.9	ND	.013		.41

ND, nondetectable.
NS, no sample.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroids, Summary of Program Operations, 1963-1969

Bureau of Radiological Health
U.S. Public Health Service

A program to supplement existing environmental radiation surveillance activities, by collecting and analyzing bovine thyroids for iodine-131, was initiated in September 1962 on a pilot scale. The major planned objectives of the program were: (1) to establish methods for collection and analysis of bovine thyroids for the purpose of instituting an operational surveillance network, and (2) to provide a basis for developing a mathematical model relating iodine-131 concentrations in the bovine thyroid to those in milk, which might make it possible to estimate retrospectively iodine-131 levels in milk for the period 1952 to 1957, when bovine thyroids were analyzed for iodine-131 but milk was not.

The program, conducted in cooperation with the Meat Inspection Division, U.S. Department of Agriculture, was initiated with Salt Lake City, Utah, and Des Moines, Iowa, as collection points. In October 1962, Seattle, Wash., was added. In April 1963, the program was expanded to include areas where cows are on pasture all year and where many brucellosis and tuberculosis reactors come to slaughter. The added stations were Montgomery, Ala.; Atlanta, Ga.; New Orleans, La.; Jackson, Miss.; Oklahoma City, Okla.; and Dallas-Fort Worth, Tex. Modifications were subsequently made in the program to include additional collection areas, and therefore, broader coverage. Some of the collection areas were in locations which are in the PHS Pasteurized Milk Network; this was expected to be useful in obtaining comparable data for iodine-131 in milk and in bovine thyroids.

Because of the low levels of radioactivity detected during preceding periods, the program was discontinued as of March 1, 1969. Provisions have been made to resume sampling of bovine thyroids if environmental levels of iodine-131 increase significantly in the future.

Program summary

During the period from September 1962 through February 1969, the bovine thyroid collection and analysis program underwent a number of changes. The early months of the program were devoted to establishing procedures for the collection of thyroid glands and performing analyses for iodine-131. By the end of January 1963, the program became operational and the results of the findings for the period, January 20 to June 29, 1963, were published in October 1963 (*1*).

By the end of 1963, iodine-131 levels were generally down to the limit of reliability in detection, and the program was temporarily suspended through September 1964. It was resumed in October 1964 and continued through February 1969. During this period the influx of iodine-131 was detected following a number of foreign atmospheric nuclear detonations. In all, a total of 15,300 bovine thyroids were collected and analyzed for iodine-131.

The sampling and analytical procedures and discussions of error factors were published in early reports on the program (*1-3*). Data developed during the operation of the bovine thyroid program appeared in these and in subsequent issues of *Radiological Health Data and Reports* (*4-15*).

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Table 1. General summary of program for analysis of bovine thyroids for iodine-131

Period covered	Number of thyroids analysed	Origin of samples by State or region	Remarks
Jan 20–June 29, 1963	760	Ala., Ark., Colo., Ga., Idaho, Iowa, Kans., La., Miss., Mo., Okla., Tenn., Tex., Utah, Wash., Wyo.	427 from lactating cows; 333 from nonlactating cows. The highest levels were recorded during January and February, principally in the Des Moines, Iowa, and Kansas City, Mo., milksheds. Fifteen specimens had values over 100 pCi/g thyroid, including 3 having levels of 202, 240, and 378 pCi/g.
June 30, 1963–Jan 3, 1964	1,445	Ala., Ark., Colo., Fla., Ga., Idaho, Iowa, Kans., La., Miss., Mo., Mont., Nebr., Okla., S. Dak., Tenn., Tex., Utah, Wash.	875 from lactating cows; 570 from nonlactating cows. Iodine-131 concentrations during this period were generally down to the limit of reliability.
Jan 4–Sept 1964			Program temporarily suspended
Oct–Dec 1964	229	Calif., Colo., Ga., Idaho, Ill., Iowa, Kans., Ky., Minn., Miss., Mont., N.Y., S. Dak., Tenn., Tex., Utah, Vt., Wash., Wis., Wyo.	Iodine-131 activity detected following October 16, 1964, atmospheric nuclear detonation on Chinese mainland. Levels were particularly high in Colorado and New York.
Jan–June 1965	1,165	Ariz., Calif., Colo., Ga., Idaho, Iowa, Kans., Ky., Minn., Miss., N. Mex., N.Y., N. Dak., Okla., S.C., S. Dak., Tenn., Tex., Utah, Vt., Wyo.	Influx of iodine-131 from mainland China atmospheric detonation of May 14, 1965, was clearly evident in June samples.
July–Dec 1965	1,602	(1) Calif.; (2) Wash., Idaho, Utah; (3) Colo., N. Mex., western Nebr; (4) N. Dak., S. Dak., Minn., Iowa, Ill., Wis. Kans., northwest Ind.; (5) Ark., Miss., (6) Tenn., Ky., Ga., southern Ind., western N.C., (7) N.Y., Vt.	Reporting by geographic grouping of States instituted. Several samples from California (Fresno, Merced, San Joaquin, Santa Clara) showed levels of 50 to 200 pCi/g thyroid, possibly resulting from a release from a nuclear facility.
Jan–June 1966	1,745	(1) Calif.; (2) Idaho, Utah, Wash.; (3) Colo., N. Mex., northwestern Tex.; western Kans.; (4) Ill.; Iowa, Kans., Minn., S. Dak., Wis.; (5) Ark., Miss., Okla., eastern Tex.; (6) Ga., N.C., S.C., (7) N.Y., Vt.	Influx of iodine-131 following a mainland China atmospheric detonation of May 9, 1966, was evident; highest average values were observed in group 3, 4, 5, 6 States, ranging from 175 to 350/g thyroid, through mid-June.
July–Dec 1966	2,370	(1) Southwestern Ariz., Calif.; (2) northern Calif.; Idaho, Nev., Ore., Utah, Wash., Wyo.; (3) northeastern Ariz., Colo., N. Mex., western Tex.; (4) Kans., Iowa, Minn., N. Dak., S. Dak., Wis.; (5) Miss., La., Okla., eastern Tex.; (6) Ga., N.C., S.C., Tenn.; (7) N.Y., Vt.	Iodine-131 levels declined to barely detectable levels in early August. New influx following Chinese test of October 27 observed through November and December, ranging up to 280 pCi/g in late November and early December.
Jan–Mar 1967	1,021	(1) Ariz., Calif.; (2) Idaho, Oreg., Utah, Wash.; (3) Colo., N. Mex., western Tex.; (4) Iowa, Kans., S. Dak., Wis.; (5) Okla., eastern Tex.; (6) Ga., N.C., S.C., Tenn.; (7) N.Y., Vt.	Influx of iodine-131 following Chinese test of December 27, 1966, was observed through January, declining to nondetectable levels by mid-February. Peak concentrations in individual thyroids ranged from about 600 to 3,260 pCi/g, and were especially high in central California and in group 2, 3, 4, and 6 States.
April–Sept 1967	1,331	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., N.C., N.Y., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Utah, Wash., Wyo.	Iodine-131 levels were generally nondetectable, although a small rise, diffused throughout the network occurred in mid to late July, with maximum levels around 20 to 25 pCi/g.
Oct–Dec 1967	647	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Nebr., Nev., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Levels were nondetectable, except for one sample (Cooke County, Texas), which contained 15 pCi/g.
Jan–Mar 1968	498	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Moderate elevations of iodine-131 were found in 8 States during parts of January and February. The most active sample was collected in South Dakota, January 24, and contained 83 pCi/g.
Apr–June 1968	502	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Nebr., N.Y., N.C., Okla., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Levels were generally undetectable; one sample (Walla Walla, Wash.) showed a level of 7 pCi/g.
July–Sept 1968	846	Ariz., Ark., Calif., Colo., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Mo., Nebr., N. Mex., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis., Wyo.	Moderate elevations were found in 11 States; the most active was collected in Garfield County, Colo., on July 30, and contained 44 pCi/g.
Oct–Dec 1968	696	Ariz., Calif., Colo., Ga., Idaho, Iowa, La., Minn., Miss., Nebr., N. Mex., N.Y., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis., Wyo.	Levels were for the most part low or nondetectable. Two samples (Maricopa, Ariz., and Mesa, Colo.) showed levels of 31 pCi/g on Oct. 4.
Jan–Feb 1969	445	Ariz., Calif., Colo., Ga., Idaho, La., Miss., N. Mex., N.Y., Okla., S.C., S. Dak., Tenn., Tex., Wash., Wis., Wyo.	Minor elevations were found in 10 States. The most active samples were in Delta County, Colo., and Washington County, Idaho, on January 3. The levels were 23 and 36 pCi/g, respectively.

Review of findings

A general summary of the findings of the program is presented in table 1. Because of changes in the geographic alignment of the sampling locations during the course of the program and in emphasis with respect to some parameters investigated, no attempt will be made to summarize the data. The individual reports should be consulted for the actual values obtained and for discussions of factors that might assist in placing the data into perspective. A number of conclusions, some of them confirmatory of studies reported by other investigators, may be drawn from the results of the determinations of iodine-131 in bovine thyroids.

1. The collection and analysis of bovine thyroids is an extremely sensitive method for the detection of intrusions of iodine-131 into the environment. Based on an earlier calculation (*16*) that milk levels (in pCi/liter) are, on the average, about 8 percent of the thyroid levels (in pCi/g) for iodine-131, then the lower limit of reliability for thyroid determinations would be equivalent to about 0.6 pCi/liter of milk. The data resulting from the bovine thyroid program were too scattered and variable to confirm this ratio; nevertheless, comparisons made in milkshed areas where cows were grazing before slaughter showed substantially higher (averaging something like an order of magnitude) iodine-131 values in thyroids than in milk following a foreign atmospheric nuclear test (*3*). Moreover, the increases in air radioactivity levels at the same locations were either slight or barely detectable, although they occurred sooner than the peak levels in the bovine thyroids.

2. Analyses of bovine thyroids for iodine-131 do not provide as quick a response to the intrusion of fresh fission products into the environment as the determination of radioactivity in air. It cannot, therefore, serve as an alerting approach; however, it is specific for iodine-131 and for that reason is a highly useful supplementary environmental assessment mechanism.

3. The study provided information that may be applied to studies involving considerations of metabolic and meteorologic pathways whereby intrusions of iodine-131 affect man. Among other things, it was determined that the effective half-life of iodine-131 in bovine thyroids ranged from 3 to 6 days (*3*). This closely parallels the data reported by the Federal Radiation Council for milk after deposition of this radionuclide on pasture (*17*). It may also be of interest that, in most of the locations for which the appropriate data were reported, the iodine-131 levels were higher in nonlactating cows than in lactating cows. The development of a model to relate iodine-131 concentrations in bovine thyroids to those in milk has not been undertaken to date; however, some rough correlations have appeared. These may be useful in estimating retrospectively the iodine-131 concentrations in milk in areas where bovine thyroid estimates were made prior to the initiation of milk-monitoring programs.

4. Guidelines were established which will facilitate a resumption of analyses for iodine-131 in bovine thyroids should such an action be indicated. The sensitivity and specificity of this procedure favor it as an adjunct to other environmental surveillance activities in identifying a fresh fission product intrusion. In at least one instance during the operation of the bovine thyroid program, iodine-131 was detected in bovine thyroids at a sampling location after a foreign nuclear test, while milk samples taken from the same pasture area failed to reveal evidence of the radionuclide (*3*).

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Strontium-90 in Human Bone, July-September 1969[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the third quarter (July–September) of 1969 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

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[1] Period during which death or surgical procedure occurred.

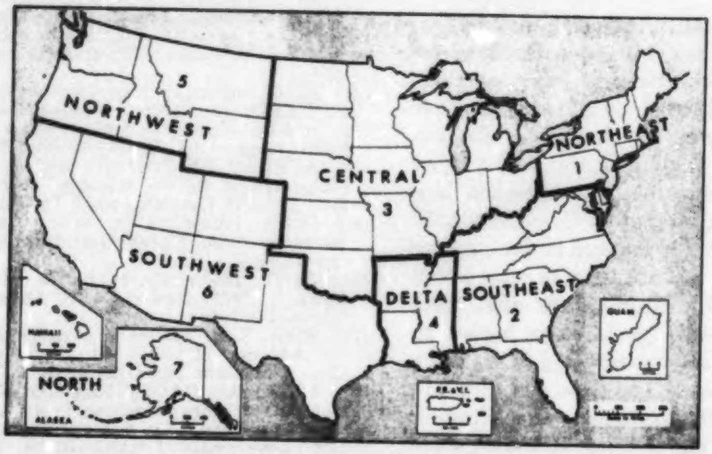

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, July-September 1969

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
New York	V	4	M	44.3 ± 6.7	28.2	1.57
New Jersey	V,R	5	M	41.9 ± 6.0	16.3	2.57
New York	V	9	M	64.8 ± 8.1	40.9	1.58
Vermont	V	10	M	68.9 ± 6.8	42.3	1.63
New York	V	12	F	73.1 ± 8.6	43.2	1.69
	V	12	F	168.0 ± 14.0	69.3	2.42
	V	13	M	35.3 ± 5.8	24.5	1.43
Pennsylvania	V	14	M	94.4 ± 8.5	41.6	2.26
Massachusetts	V	18	M	120.0 ± 11.0	48.9	2.45
New York	V	19	M	97.3 ± 9.7	64.6	1.50
	V	20	M	72.8 ± 8.3	57.6	1.26
	V	21	F	100.0 ± 9.1	56.4	1.77
Southeast:						
North Carolina	V	1	F	244.0 ± 18.0	40.3	6.05
South Carolina	V	1	M	127.0 ± 11.0	25.4	5.00
North Carolina	V	5	M	97.4 ± 8.0	32.1	3.03
Maryland	V	6	M	76.5 ± 11.0	33.5	2.28
	V	9	F	99.7 ± 10.0	34.6	2.88
	V	10	M	91.0 ± 11.0	37.8	2.40
	V	16	M	145.0 ± 14.0	61.6	2.35
	V	17	M	78.5 ± 11.0	53.3	1.47
	V	17	M	107.0 ± 12.0	49.3	2.17
	V	17	M	92.1 ± 12.0	45.0	2.04
South Carolina	V	17	M	173.0 ± 12.0	54.1	3.19
Maryland	V	18	M	81.5 ± 11.0	51.2	1.59
	V	18	M	136.0 ± 14.0	66.0	2.06
North Carolina	V	18	M	130.0 ± 12.0	38.0	3.42
Maryland	V	18	M	161.0 ± 13.0	59.8	2.69
Georgia	V	19	M	96.8 ± 9.5	63.2	1.53
South Carolina	V	19	M	85.5 ± 9.7	42.4	2.01
Maryland	V	19	M	136.0 ± 12.0	64.2	2.11
	V	20	M	304.0 ± 20.0	76.2	3.98
	V	20	M	154.0 ± 17.0	73.7	2.08
	V	20	M	93.2 ± 10.0	61.0	1.53
	IS	21	M	154.0 ± 14.0	45.7	3.36
	V	21	M	109.0 ± 11.0	49.6	2.19
	V	23	M	103.0 ± 11.0	49.5	2.08
Georgia	V	24	F	80.2 ± 10.0	49.2	1.63
Maryland	V	25	M	69.6 ± 9.5	52.3	1.33
	V	25	M	118.0 ± 11.0	53.7	2.23
Central:						
Wisconsin	V	1	F	65.3 ± 10.0	36.1	1.80
Minnesota	V	4	F	106.0 ± 10.0	30.9	3.43
Wisconsin	V	5	F	73.8 ± 7.8	42.5	1.73
Minnesota	V	7	M	111.0 ± 8.8	34.7	3.19
Wisconsin	V	7	F	134.0 ± 11.0	47.6	2.81
Minnesota	V	8	M	49.1 ± 6.6	29.3	1.67
Wisconsin	V	8	M	71.9 ± 9.7	42.7	1.68
Minnesota	V	10	M	81.6 ± 10.0	43.9	1.86
Ohio	V	10	M	91.8 ± 10.0	34.5	2.66
	V	10	M	74.7 ± 10.0	39.8	1.87
	V	12	F	73.9 ± 6.6	41.2	1.79
	V	14	M	118.0 ± 13.0	50.7	2.33
	V	14	M	138.0 ± 11.0	43.7	3.15
	V	15	M	90.3 ± 8.7	49.5	1.82
	V	15	M	144.0 ± 12.0	44.9	3.20
	V	16	M	120.0 ± 13.0	54.5	2.20
	V	17	F	189.0 ± 12.0	68.6	2.75
Michigan	V	17	M	121.0 ± 11.0	71.7	1.68
Ohio	V	18	M	105.0 ± 11.0	64.2	1.63
	V	18	M	112.0 ± 11.0	56.0	2.00
	V	19	M	193.0 ± 16.0	61.0	3.16
	V	19	F	140.0 ± 12.0	63.8	2.19
	V	19	F	101.0 ± 10.0	50.9	1.98
	V	20	M	103.0 ± 10.0	55.1	1.86
	V	20	M	116.0 ± 10.0	61.3	1.89
Iowa	V	20	M	123.0 ± 13.0	53.2	2.31
Ohio	V	21	M	113.0 ± 12.0	55.7	2.03
	V	21	F	119.0 ± 11.0	53.3	2.23
	V	21	M	126.0 ± 13.0	61.5	2.04
Michigan	V	22	F	66.8 ± 7.5	47.5	1.40
Ohio	V	22	F	72.5 ± 10.0	54.7	1.32
	V	22	M	73.5 ± 9.9	49.6	1.48
Minnesota	V	22	F	95.8 ± 9.0	55.1	1.73
Ohio	V	23	M	84.4 ± 8.2	62.3	1.35
Michigan	V	24	F	132.0 ± 14.0	70.0	1.88
	V	24	M	111.0 ± 12.0	68.8	1.61
Ohio	V	24	M	89.7 ± 12.0	56.7	1.58
Northwest:						
Oregon	V	3	F	49.7 ± 7.2	32.2	1.54
	V	6	M	60.3 ± 9.1	32.7	1.84
	V	8	M	55.4 ± 6.6	26.0	2.13
	V	16	M	85.7 ± 10.0	54.9	1.56

See footnotes at end of table.

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Table 1. Strontium-90 in human bone, July–September 1969—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Oregon	V	17	M	104.0±11.0	48.8	2.13
	V	17	F	93.3± 8.4	54.9	1.70
	V	17	M	58.4± 6.3	34.8	1.67
	V	17	F	75.6±10.0	52.3	1.44
Washington	R	17	M	91.8± 8.7	40.9	2.24
Oregon	V	18	F	88.3± 8.3	45.5	1.93
	V	19	M	38.8± 5.8	25.0	1.55
	V	19	M	61.2± 6.1	43.3	1.41
	V	21	M	84.1±10.0	54.8	1.53
	V	22	F	80.1±11.0	58.9	1.35
	V	23	M	69.0± 9.6	44.8	1.54
	V	24	M	49.8± 5.6	49.9	.99
	V	25	M	59.8± 9.7	58.2	1.02
Southwest:						
California	V	21	F	49.4± 7.4	47.3	1.04

[a] Type of bone, V, vertebrae; R, rib; IS, ischium.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1968	December 1969
January–March 1969	March 1970
April–June 1969	May 1970

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(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M. and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

(*6*) BARATTA, E. J., E. S. FERRI, and M. A. WALL Strontium-90 in human bones in the United States, 1962–1966. Radiol Health Data Rep 11:183–186 (April 1970).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Mound Laboratory and the National Reactor Testing Station.

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[1] Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Mound Laboratory[3]
January–June 1969

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and tritium (hydrogen-3) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction, it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. The remaining three fourths of each filter paper is processed chemically to remove polonium. The remaining alpha radioactivity is interpreted as plutonium; however, some of this alpha radioactivity is probably due to naturally occurring alpha-particle emitters.

Airborne tritium is monitored by bubbling air through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is counted directly in a liquid spectrometer.

The results of the airborne monitoring program are presented in tables 1, 2, and 3. The average concentrations of plutonium, polonium, and tritium, in the environment are below the AEC radiation protection standards.

Table 1. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	30.5	16.3	0.08
0–3 (downwind)	24	25.8	9.9	.05
3–5 (downwind)	23	25.9	14.5	.07
5–10 (downwind)	24	22.6	14.4	.07
10–15 (downwind)	25	30.2	15.8	.08
15–20 (downwind)	24	25.7	12.4	.06

[a] Lowest detectable level (LDL) for polonium-210 in air is 8.0 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. Allvalues which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m^3.

Table 2. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	10.8	5.1	0.51
0–3 (downwind)	24	61.1	7.3	.73
3–5 (downwind)	24	183.2	12.0	1.20
5–10 (downwind)	23	12.6	4.7	.47
10–15 (downwind)	24	15.3	5.0	.50
15–20 (downwind)	24	15.6	3.6	.36

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 70 fCi/m^3.

Table 3. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (nCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	23	4.91	1.33	0.66
0–3 (downwind)	23	12.19	1.61	.80
3–5 (downwind)	22	1.68	1.06	.53
5–10 (downwind)	23	1.45	1.04	.52
10–15 (downwind)	22	1.09	1.00	.50
15–20 (downwind)	22	3.58	1.14	.57

[a] Lowest detectable limit for tritium in air is 1.00 nCi/m^3. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m^3.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

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[3] Summarized from "Environmental Monitoring Report: January–June 1969" (MLM–1615).

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and is discharged to the drainage ditch which runs through the site and eventually reaches the river. Some tritium-contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Water samples are collected weekly from the Great Miami River, the drainage ditch, and two ponds northeast of Mound Laboratory (figure 1). The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 4 for January–June 1969.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	May 1969
July–December 1968	December 1969

Table 4. Offsite water monitoring for radioactivity, Mound Laboratory environs, January–June 1969

Radionuclide and sampling locations[a]	Number of samples	Concentration	
		Maximum	Average[b]
Polonium-210:[c] (pCi/liter)			
1 (Drainage ditch)	24	38.04	4.90
2 (Upstream from laboratory)	24	2.70	1.84
3 (Laboratory effluent)	24	2,117.12	267.94
4 (250-yards downstream)	24	20.73	4.39
5 (Chautauqua Road Bridge)	24	371.17	17.23
6 (Chautauqua Dam)	24	6.31	1.99
7 (Franklin, Ohio)	24	<1.80	1.80
8 (Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	<1.80	1.80
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	<1.80	1.80
Plutonium-238:[c] (pCi/liter)			
1 (Drainage ditch)	24	472.71	65.01
2 (Upstream from laboratory)	24	6.98	4.65
3 (Laboratory effluent)	23	519.14	66.60
4 (250-yards downstream)	25	8.93	5.38
5 (Chautauqua Road Bridge)	25	48.65	6.88
6 (Chautauqua Dam)	25	6.19	4.76
7 (Franklin, Ohio)	24	7.17	4.85
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	6.34	4.63
9 (Pond, Possum Creek Reserve, Dayton Ohio, 6 miles NE of Mound Laboratory)	23	10.32	5.14
Tritium[c] (hydrogen-3): (μCi/liter)			
1 (Drainage ditch)	24	22.97	2.47
2 (Upstream from Laboratory)	24	.88	.13
3 (Laboratory effluent)	24	15.97	1.64
4 (250-yards downstream)	24	.72	.09
5 (Chautauqua Road Bridge)	24	3.67	.22
6 (Chautauqua Dam)	24	.38	.08
7 (Franklin, Ohio)	24	1.74	.17
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	22	.22	.08
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	.77	.10

[a] See figure 1 for number of sampling locations.

[b] The applicable AEC radiation protection standards for uncontolled area are as follows:
Polonium-210 in water: 700 pCi/liter.
Plutonium-238 in water: 5 nCi/liter.
Tritium in water: 3 μCi/liter.

[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for plutonium-238 in water is 4.5 pCi/liter.
Minimum detectable level for tritium in water is 50 nCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

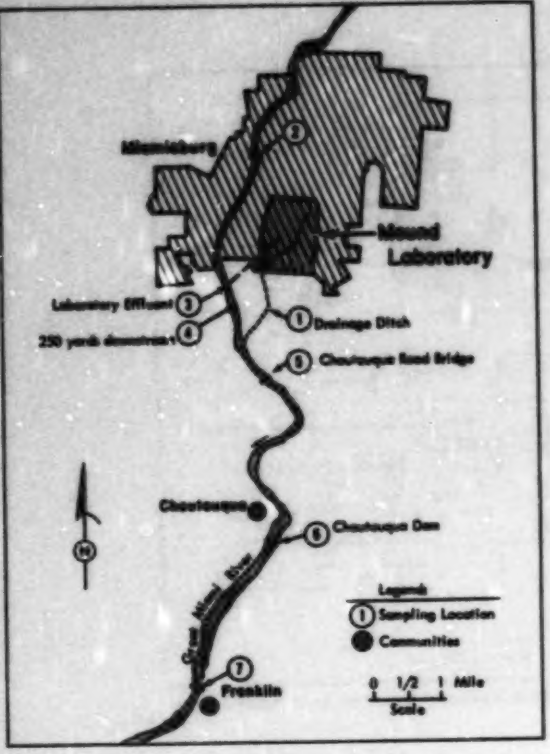

Figure 1. Water sampling locations, Mound Laboratory

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2. National Reactor Testing Station[2]
July–December 1968

Health Services Laboratory
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the second half of 1968 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the Atomic Energy Commission standards as set forth in AEC Manual Chapter 0524. These standards are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium-226 or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources, such as fallout and natural radioactivity. Samples of air, water and milk are collected routinely at stations shown in figure 2. The results of the analyses performed on the air, water, and milk samples are shown in table 5 for July–December 1968 and table 6 for the year 1968.

Water monitoring

Liquid wastes containing small quantities of radioactivity from various operating facilities at NRTS are released to the ground-water table through disposal wells and seepage ponds located near each facility. Before disposal, the liquid wastes are monitored at NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map plus the onsite samples, provide adequate information on the underground water leaving NRTS. A total of 22 onsite production wells are sampled twice monthly. The offsite underground water is sampled at 12 locations. Offsite surface water samples are collected from the Snake River at Idaho Falls and Bliss, Idaho. The offsite water sampling frequency is once every 6 months.

Air monitoring

The filters from air samplers, operated continuously, are collected and analyzed weekly. These filters are analyzed for gross alpha, gross beta, and iodine-131 radioactivity. A total of nine sampling locations are used for reporting the concentration of air radioactivity. The eight onsite sampling locations and Idaho Falls are shown in figure 2. The offsite concentrations indicate the level of radioactivity from natural and nuclear fallout material. During 1968, the average concentration of gross beta radioactivity onsite

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[2] Summarized from "Environmental Monitoring Report No. 23, July–December and Annual Summary—1968," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory, National Reactor Testing Station.

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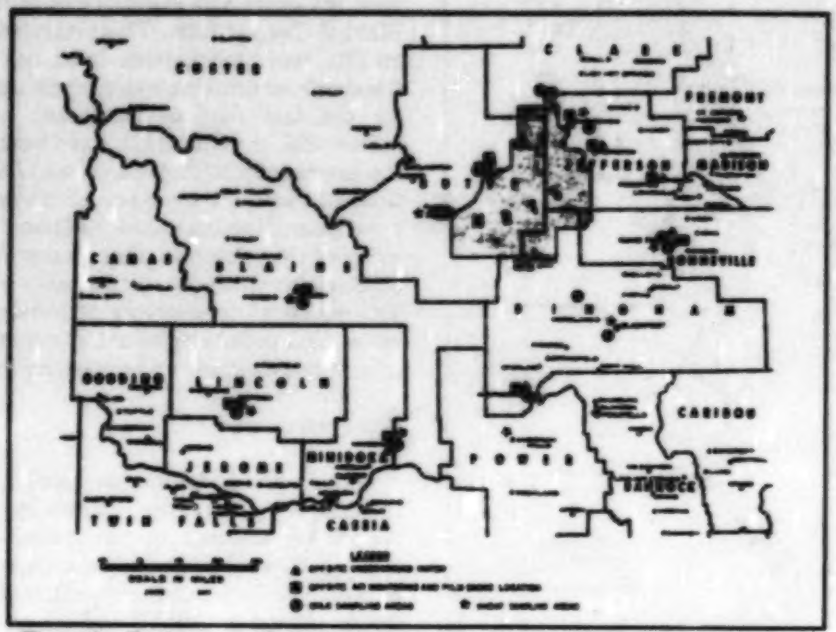

Figure 2. Environmental monitoring stations, National Reactor Testing Stations

Table 5. Environmental monitoring data for the National Reactor Testing Station, July–December 1968

Type of sample and units	Number of samples	Type of radioactivity	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC Standard
Onsite production well water (pCi/liter except tritium)	251	Alpha	3	10	<3	3,000
		Beta	5	30	<6	3,000
		Tritium (nCi/liter)	2	340	11.8	100,000
Offsite underground water (pCi/liter except tritium)	12	Alpha	3	5	<3	100
		Beta	5	7	<5	100
		Tritium (nCi/liter)	2	<2	<2	3,000
Surface water (pCi/liter except tritium)	2	Alpha	3	<3	<3	100
		Beta	5	<5	<5	100
		Tritium (nCi/liter)	2	<2	<2	3,000
Onsite air (pCi/m³)	208	Alpha	0.001	0.002	0.002	1
	216	Beta	.003	13.6	.63	300
	186	Iodine-131	.01	.82	.04	9,000
Offsite air (pCi/m³)	26	Alpha	.001	.005	.003	0.04
	26	Beta	.003	11.0	.59	10
	26	Iodine-131	.01	.07	< .02	100
Offsite milk (pCi/liter)	80	Iodine-131	20	<20	<20	100
	12	Strontium-90	1	4	<3	200
Offsite area monitoring badges (mR)	12	Gamma	5	45	<31	85
Offsite, wheat	6	Strontium-90	2	10	<5	none

was 25 percent higher than the average background concentration measured in Idaho Falls. This difference is attributed to operations at the site. On the other hand, the average yearly concentration of gross alpha radioactivity in Idaho Falls is 34 percent higher than that at the site. Investigations are underway to find the source of this higher gross alpha concentration in Idaho Falls. All monitoring results are listed in tables 5 and 6.

Offsite milk monitoring

Offsite milk samples are collected from 12 locations routinely and analyzed for strontium-90

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Table 6. Environmental monitoring data for the National Reactor Testing Station, January–December 1968

Type of sample and units	Number of samples	Type of radioactivity	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC Standard
Onsite production well water (pCi/liter, except tritium)	469	Alpha	3	9.0	<3.1	3,000
	469	Beta	5	38	<6.0	3,000
	487	Tritium (nCi/liter)	2	340	10.9	100,000
Offsite underground water (pCi/liter, except tritium)	24	Alpha	2	3.3	<2.2	100
	24	Beta	5	6.8	<5.3	100
	24	Tritium (nCi/liter)	2	<2	<2	3,000
Surface water (pCi/liter, except tritium)	4	Alpha	3	4.4	<3.5	100
	4	Beta	5	<5	<5.0	100
	4	Tritium (nCi/liter)	2	<2	<2	3,000
Onsite air (pCi/m³)	406	Alpha	.001	.007	.0022	1
	432	Beta	.005	13.6	.04	30
	288	Iodine-131	.01	5.16	< .05	9,000
Offsite air (pCi/m³)	52	Alpha	.001	.026	.0030	0.04
	55	Beta	.005	11.0	.01	10
	46	Iodine-131	.01	.16	< .02	100
Offsite milk (pCi/liter)	179	Iodine-131	20	20	<20	100
	24	Strontium-90	1	10	<4	200
Offsite area monitoring badges (mR)	25	Gamma	10	145	<40	170

and iodine-131. A composite grade A sample is collected weekly from an Idaho Falls dairy. This composite sample contains milk from areas north and south of Idaho Falls. Milk samples are collected monthly from all sampling locations. The sampling locations are shown in figure 2 and the results are given in tables 5 and 6. No iodine-131 was detected at any time during the year. The strontium-90 concentrations are attributed to worldwide fallout.

Gamma radiation levels

Semiannual measurements (table 5) of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 12 offsite locations during July–December 1968.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 50–150 mR/a. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Wheat monitoring

Wheat samples were collected from six different locations during the 1968 fall harvest. The sampling locations are shown in figure 2, and the analysis results in tables 5 and 6. The wheat hull has been found to contain approximately 90 percent of the strontium-90. This means that only 10 percent of the measured radioactivity remains with the wheat after processing. As in milk, the concentration of strontium-90 in wheat is the result of worldwide fallout.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Calendar year 1967	October 1968
January–June 1968	August 1969

Reported Nuclear Detonations, May 1970

(Includes seismic signals from foreign test areas)

During May 1970, nine United States nuclear tests at the Nevada Test Site were announced by the U. S. Atomic Energy Commission. Two low yield tests (less than 20 kilotons TNT equivalent) were conducted underground on May 1 and one test on May 5, 1970.

An underground nuclear test with a yield of less than 20 kilotons was conducted on May 12, 1970, at the Atomic Energy Commission's Nevada Test Site as part of a Department of Defense program related to methods of detecting, identifying, and locating underground nuclear detonations.

A nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent) was conducted May 15, 1970.

Two nuclear tests were conducted underground on May 21, 1970. One was in the low yield range of less than 20 kilotons and the other test in the low-intermediate yield range between 20 to 200 kilotons.

Two underground nuclear tests with different purposes were conducted May 26, 1970, by the Atomic Energy Commission at its Nevada Test Site. One was weapons related and in the low yield range of less than 20 kilotons. A small amount of radioactivity seeped to the atmosphere following this test of May 26, 1970. No radioactivity has been detected beyond the immediate vicinity of the test.

The other nuclear test was part of the Commission's Plowshare Program to develop nuclear explosives especially designed for peaceful uses. This test is one of a series developed for the possible use in excavation experiments. Following this second test on May 26, 1970, a slight release of radioactivity to the atmosphere took place. There was no release of radioactivity as a result of the detonation itself and the radioactivity was measurable only in the immediate vicinity of the sampling effort, well within the boundaries of the test site. Neither release resulted in any health hazard to personnel at the site.

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